# ENGINEERING

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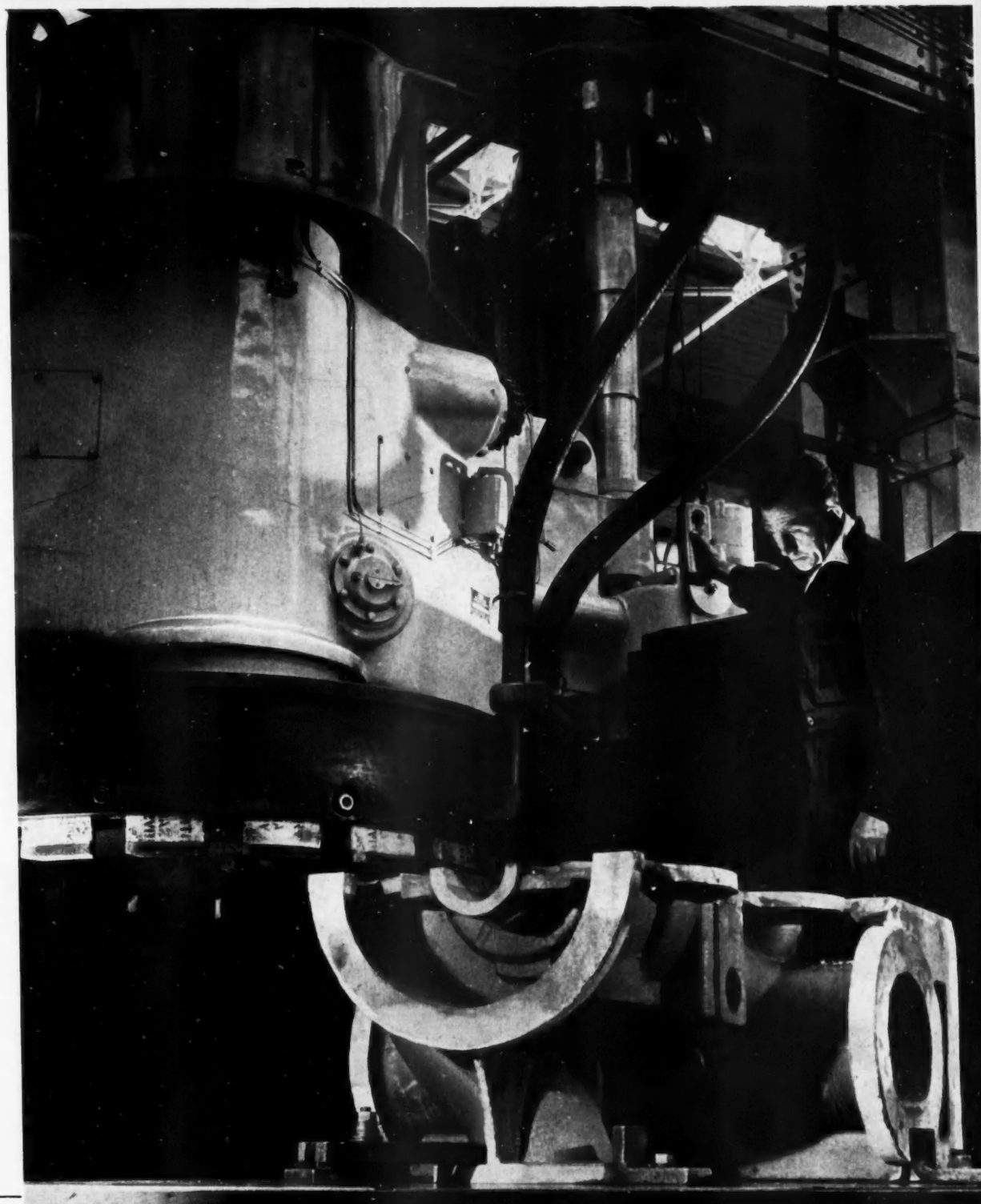

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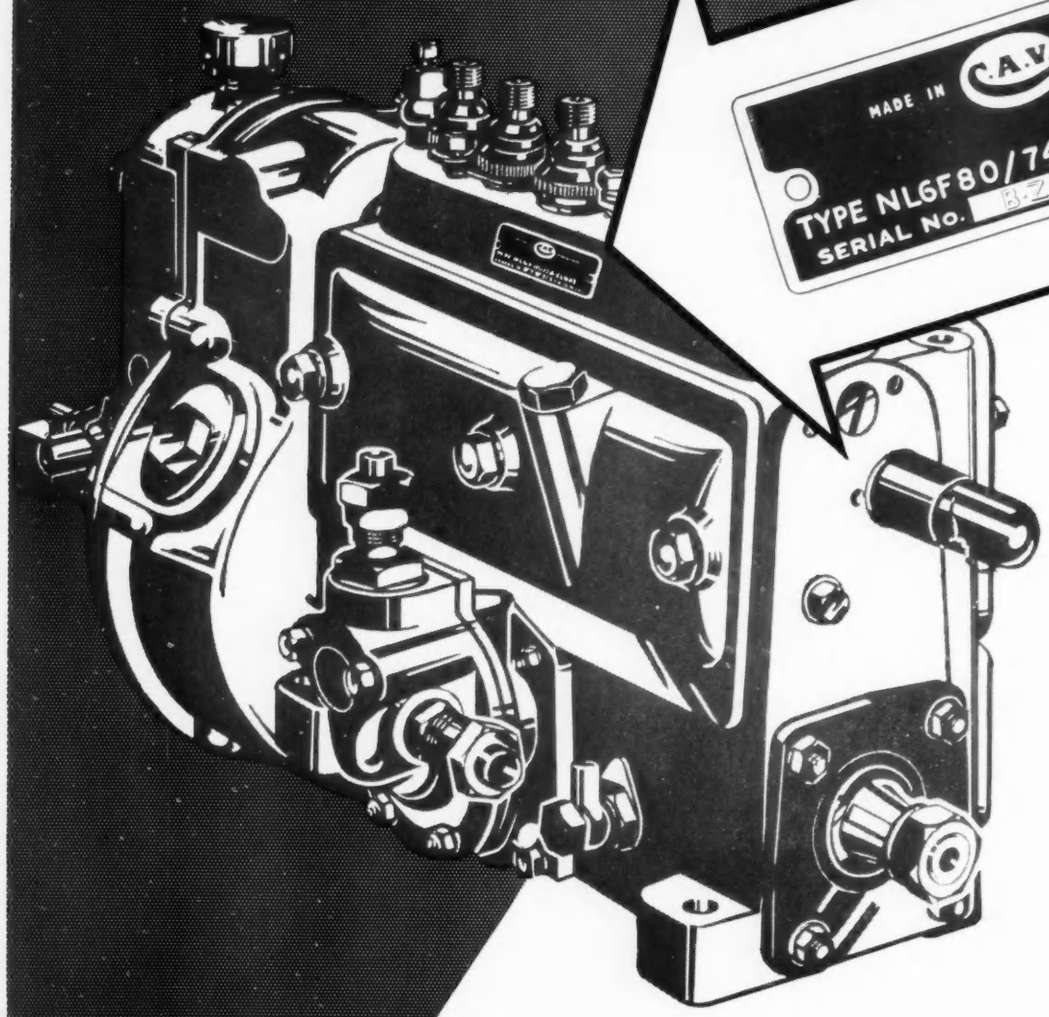


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ENGINEERING
PUBLISHED EVERY FRIDAY

Vol. 185 No. 4811 23 May 1958

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# Constant Change

FINANCIAL help from the Government towards industrial research is characteristic of Britain's political development. It enables research to be carried out which could not be done by industry alone, but it is conditional on industry doing as much as possible to help itself. Behind the scenes, numerous committees are charged with the many tasks of reviewing research policy, allocating funds and dealing with all the questions which arise. From the office of the Lord President of the Council to the board rooms of companies, responsibility is de-centralised throughout the Government, the Civil Service and industry. It is a splendid example of democracy at work.

In this issue of ENGINEERING, Lord Halsbury contributes a stimulating review of the organisation of the Department of Scientific and Industrial Research. He is by no means hyper-critical; indeed he shuns any criticism which fails to recognise that the DSIR is an "evolutionary" product. It may not be perfect at any given time, but it may be the most suitable working machinery which can adapt, and be adapted, with the changing requirements of the State and the industries it serves. "Like our system for financing education," he remarks, "it cannot be easily explained on a sheet of notepaper with the aid of a conventional 'responsibility' chart. The only satisfactory way to learn it is to work with it. Some proposals for reform to which I have listened from time to time appear designed less to improve the machine from the administrative angle than to render it more readily explicable to the casual inquirer. Evolution and growth always undo such reforms, which can therefore serve only transient purposes."

A built-in capacity for evolution and growth is perhaps the first essential in the organisation of the DSIR. The Lord President, Viscount Hailsham, has recently raised an important principle, the application of which will affect the working of his department. Speaking at the annual luncheon of the Electrical Research Association, he suggested that industry's financial contribution to the work of the research association was on too small a scale. Other great research associations, he pointed out, received as much as £3, or even £6, from their industrial members for every £1 grant from the Government, whereas the ERA received only £2·4. But is this the whole truth? Is a direct comparison fair and realistic? It is certainly not reasonable to ignore the fact that manufacturing firms in the electrical industry carry out a considerable amount of research privately—probably much more, relatively, than most other industries. Indeed, of all the scientists and engineers in electrical engineering, 58 per cent are engaged on research and development work—a figure only exceeded by the aircraft industry and the comparatively small precision instruments industry. The average proportion for all industries is only 45 per cent, and some are below 10 per cent.

The research associations work on the principle of co-operative research; with the money they receive from their industries and the Government, they carry out a programme of research which is determined by representatives of the contributing parties. But co-operative research is obviously only acceptable to industrial firms where the work cannot conveniently be carried out by the one or two firms who are directly interested. Since commercial success in engineering is often dependent on advanced research, a company would prefer to do research itself for itself, rather than see it done for a whole group of companies, including its competitors. In some industries, therefore, the research associations may be confined to marginal projects which, for one reason or another, the companies prefer to be done on a co-operative basis. There is nothing anti-social or detrimental to the welfare of the country in this attitude.

The Lord President hopes that industry will shoulder more responsibility for research in the future. What was for the benefit of industry, he said, should look primarily to industry for finance; it was neither possible nor desirable for Government to do what was essentially industry's job. It was industry's job in applied science both to ask the right questions and make the right use of the answers when they came. This expectation was certainly more in accord with the Government's philosophy than his failure to recognise that, as far as possible, companies should do their own research. The urgent need is to assist small and medium firms to participate directly in research and research planning. That can only be done by ensuring that selected representatives of such firms have a greater say in committees which do the planning. They can help to make research more down-to-earth and practical. The new Research Council of the DSIR, in their first report, have indicated that they will soon be examining the whole question of industry's part in financing co-operative research programmes. The time is clearly ripe for some evolutionary changes.

**Cover Picture:** *The mating faces of a pump casing need to be accurately machined. The illustration shows such a casing being lined up on the table of a* 100 *h.p. grinder with a* 55 *in wheel. (Nurnberg photograph for* ENGINEERING.)

* * *

# Plain Words

The school chemistry laboratory was, I suppose, the first introduction for most of us to "science." It was rather a disappointing place. One would have thought that with all those bottles, balances and carboys, there was a chance of witnessing at least a minor explosion; a chance, perhaps, of doing something original and spectacular. But chemistry masters seemed to think in terms of rigidly controlled experiments, which had been done on countless previous occasions by earlier generations of schoolboys. The Christmas present of a chemistry set was even more frustrating. A branch of science which ought to have been exciting turned out to be very tame. No wonder we became engineers.

I am not looking back in anger, only in regret—regret that it is so difficult to satisfy a schoolboy's interest in science and engineering. What makes me look back is the Institution of Mechanical Engineers' announcement that they are producing an *aide-mémoire* on the planning of mechanical engineering teaching laboratories. They invite engineers to contribute ideas which can be incorporated.

A friend who has some experience of these matters says it is necessary to be clear as to the kind of teaching the laboratories are to be used for. Is the laboratory to be a place where students may do real experimentation, or where they do little more than verify what someone has told them in lectures or in a book? "Anyone who has used a piece of chalk," he suggested, "will insist that all future lecture rooms should be equipped with a gadget which permits diagrams to be done in comfort while facing the audience, to appear projected on the wall behind." (Remembering the kind of tricks we used to play while the lecturer's back was turned, I can well appreciate his anxiety.) My heart sank again, as it used to with the approach of examinations, when he said the architect must solve the problem of the lecture theatre which can be used as an examination room. The dividing line between the architect's and the engineer's responsibilities is not very clear (because, of course, there must be co-operation), but he remarked that "any engineer who has had to put up laboratories is only too well aware that no architect is competent in the detailed planning of services, and that unless minutely supervised, will cheerfully put up a building merely to hack it about once more to do the work that any competent engineer would have planned in advance. In this he will be ably abetted by the builder!" There is really little excuse for these follies, and there will be none at all if the Institution get a good response to their request for advice based on experience.

CAPRICORN

## Weekly Survey

# *Too Serious for Scientists?*

Under the current defence controversies, whether over the bomb or supersonic bombers, lies a nagging doubt as to who, if anyone, in a democracy is best able or indeed able in any way to decide on defence policy in the nuclear era. The engineer or scientist whose successful project has been derided in its infancy may have justification for accusing Authority of consisting of short-sighted amateurs. In the field of armaments his job is to produce a revolutionary weapon. In the nature of things he will believe in it, sometimes passionately, and argument based on faith has great persuasive power. In technical matters, a politician is an amateur; this is no slight—even with a technical background, specialisation makes it well nigh impossible for a man with broad responsibilities to be other than an amateur in a particular field. Faced with a host of projects (some hare-brained, and many honest but unworkable for unforeseen reasons) he must rely on specialist advice, and may be forgiven for growing cynical with age. The Services, charged with the job of using the weapons, are in many ways best able to decide on the merits of any one of them, once made, but not necessarily while they are still on paper.

However honest any of these parties may be, each is strongly interested in staying in business. Thus, there is a regrettable tendency on the part of military men to say "will" and not "would" in talking of a Third World War, and an armaments contractor, such as the aircraft industry, defends its military projects to the last ditch. A Minister with an appalling responsibility to carry, must see the country defended, and at the same time satisfy the electorate. The price for the aircraft industry for being wrong is on the one hand technical oblivion and on the other hand a rapid contraction of the industry.

In this schizophrenic situation, it is honesty that is demanded above all else. Political feuds in this field, whether in Parliament or out of it, are in the present context frivolous to the point of insanity; the time is too serious. Appeals to an uninformed and confused public whether through the Press or through the House of Commons are dangerous in the extreme.

War was once the province of generals and has been declared to be too serious a matter to be left to them. It is now largely the province of scientists. The present situation leads to the feeling that it is too serious a matter not only for them, but for the politicians too if they remain only politicians. Perhaps the age of the gifted amateur is about to be reborn in this nuclear age.

## *Churchill College*

Last week it was announced that a trust has been established for the building and endowment of a new college at Cambridge which will have a strong bias towards the study of science and technology. The capital cost is put at £1·35 million with annual costs of about £105,000. An endowment fund to cover both the capital cost and a reasonable number of years of recurrent expenditure is estimated to require about £3·45 million. The trustees include a number of leaders of industry and the president of the Amalgamated Engineering Unions as well as academicians.

This new college is significant for a number of reasons. Although it will not be reserved exclusively for technical people (the proposed ratio of scientists to non-scientists is 70: 30) and although it will be administered and will function much like any other college at Cambridge, it will be reserved for the training of a scientific élite. It will indeed take one post-graduate student for every two undergraduates. One effect of this new foundation will certainly be to fortify further the lead which Cambridge has established as a centre of research.

A wider issue is also involved. The need to increase rapidly the training facilities of universities and technical colleges is now beginning to grip the public imagination. Industry has played an important part both by providing governors and advisors for administrating bodies and also in the form of grants and attractive terms of employment to trainees and apprentices who may justify expenditure of formal technical training in due course. The Government too has made its gestures in a more liberal attitude as regards grants for young men and women. So great has been the response to the need that there is danger of confusion and more good schemes being started than can ever be fully carried out. Liabilities are fast building up upon industry to assist financially and otherwise with technical training schemes, and the University Grants Committee is in some danger of being overwhelmed by the number of organisations seeking assistance and by lack of knowledge of how much help such organisations have already received and how much more they require. Some system of priorities is going to be necessary before very long.

## *Heliport for London*

The Public Inquiry opened last week into the application by Westland Aircraft to construct a heliport in Battersea. Speaking for the company at the inquiry, Mr. J. P. Widgery said that such a station in London was essential if helicopters were to be properly developed. The case for the immediate construction of a helicopter station near Central London has been cogently argued by many authorities, notably by the Helicopter Association of Great Britain. In their *Examination of the Case for a London Heliport*, published in January of this year, the Association conclude that the present MTCA attitude of relating the need for a London Heliport to the future advent of twin-engine helicopters is a mistaken policy. The report agrees that comprehensive inter-city services in all weathers will require multi-engine machines for reliability, but argues at length that existing single-engine types can operate into city centres with safety under slightly restricted weather conditions. Further, the report concludes that there will be a definite need for single-engine helicopter operations into the city centres even after the introduction of scheduled services by multi-engine types. The latter can take off and land in a relatively smaller space, so that a station constructed now for existing helicopters would be suitable for later inter-city services.

The heliport should therefore be suitable for use by present-day single-engine machines, should be alongside the River Thames, and within, at most, a 15-minute drive from Westminster at peak traffic periods.

The proposed Westland station at Battersea fulfils these requirements. It would lie about four miles by road from Westminster Abbey, on the south bank of the river between Battersea Railway Bridge and Wandsworth Bridge. Access would be by road, or perhaps more suitably in peak traffic periods by river launch—an ironical reflection on modern transport. All approaches would be over the river. Compared with the requirements of fixed-wing aircraft, the scale of construction is of course extremely modest. The total area of river bank to be used measures only 200 sq. ft, while the landing platform projects 100 ft over the river. The estimated cost of the project is £62,000, while running costs would be about £8,500 a year.

In view of the great savings in journey time from Central London which can be effected,

even using current helicopter types with an average block speed of around 80 m.p.h., it is greatly to be hoped that such a permanent station can be put in use in the near future, so that the necessary experience can be built up for future operations.

## *Chile Inflation*

Chile, one of the countries of most varied beauty in the world, includes the desert attractions of the arid nitrate pampas in the north, the majesty of Aconcagua towering above the fertile valleys of the centre, the woods and trout-filled lakes of the south and the sheep-raising country of Tierra del Fuego where missionary-shepherds looked after two sorts of flocks in the early days of settlement and found the four-legged ones considerably more repaying.

It has always attracted Britons, particularly Welshmen—though a good many families with names like Edwards can now speak little English—and immigrants tough enough to cope with life in the nitrate *oficinas* and the copper mines. Perhaps the strong bargaining power of the miners, combined with the country's continued dependence on copper and nitrate, account partly at least for the inflation which has been Chile's main problem for many years.

Some years ago Peru had the happy idea not only of calling in an American firm of business consultants, Klein and Saks, to cope with similar problems, and—less common—of taking their advice. The results were spectacular, and the *Sol* has since occupied an enviable position compared with the Chilean *Peso*. In the latest *Overseas Economic Report* (H.M.S.O., 7*s*), is described the medicine prescribed by Klein and Saks, who are striving to repeat their success in Chile, and seems to take a cautiously optimistic view of its efficacy. The main reservation concerns the tradition of budget deficits and the difficulty of putting a brake on Government expenditure. If the operation is successful perhaps we could entice a few ex-emigrants back to the old country to show us how to do it.

## *Coa at Any Price*

In 1957 the National Coal Board made a net deficit of £5·3 million. The trends which brought this about have continued into 1958 and there is every prospect of serious losses this year. Absenteeism remains at a very high level. Up to the beginning of this month the average absentee rate so far this year was 14·7 per cent compared with 13 per cent up to the same time in 1957. In addition, productivity has been at a low level between January and March, though there has been a slight improvement since.

Special steps have been taken by the Board, according to the chairman, Sir James Bowman, to make economies. The most important step towards an immediate financial saving has been the restriction in adult recruitment, so allowing natural wastage to run down the labour force. A second step has been to end the voluntary Saturday shift which would have been due for renewal at the beginning of May. A third step has been the closure of uneconomic pits. It is very apparent that were it not for the profits made on open-cast coal, the performance of the coal industry would have been even worse.

Little went right with the industry last year. Its forecast of demand was wrong. It estimated that there would be an increase of between 2 and 3 million tons in demand and there was in fact a fall of over 5 million tons.

The benefits of the long-term investment programme were obscured by the Asian flu epidemic and the high rate of voluntary absenteeism. In addition to the consequences of these problems working out on the 1958 results, there is the possibility of higher miners' wages if the tribunal decision now pending on the union's claims for shorter hours, sick pay and a wage increase is favourable to the men; also, the export market is suffering from price cutting by Poland. Under such circumstances a rise in coal prices in the domestic market becomes once more a likelihood. The fact is that the coal industry's organisational, structural and long-term investment plans have never started with an objective appreciation of the home and export market and of the intricate price and output problems which the industry is called upon to face at short notice. Instead of starting with the interrelation of price, output and investment, the industry has been forced to think in terms of human relations and "coal at any price." The industry and the rest of the industrial economy along with the taxpayer, are paying the price of that approach.

## *Steel Exports Tomorrow*

In April steel output in this country was 5 per cent lower than at the same time last year. Pig iron production was down by over 7 per cent. Exports of finished steel fell off in the first quarter of this year by about 19 per cent compared with the same quarter of 1957. The steel industry is in fact finding it increasingly difficult to sell in markets abroad where it competes with Continental producers just at the time when the level of output as a whole is easing off. There has been evidence of price cutting by Continental suppliers in markets outside Europe. This is a sharp reminder that competition from the Continental steel industry is raising considerable problems for the United Kingdom industry.

The Continental steel industry is now operating under a double impetus. On the one hand there have been the large strides made in the last few years in modernising the industry. There has been a rapid increase in the rate of vertical integration. The onset of the European Economic Community (the European Common Market) is already having a tendency to increase this process of concentration. One consequence of this is that rumours of horizontal concentration on a large scale are likely to gain rapid currency especially if the rate of increase in output of the steel industry begins to slow down as is now happening. The High Authority of the Iron and Steel Community has just denied a rumour of increased horizontal concentration in the German steel industry.

There still remains the possibility that the European Economic Community will continue to exist without the Free Trade Area being added to it. If that should happen the steel industry in this country will have to face increasingly fierce competition in markets outside Europe, without the benefit of offering competition to the Continental industry in the latter's home market on equal terms. The steel industry's interest in the Free Trade Area is likely therefore to increase in the months ahead.

## *Oldest Steam Engine*

In 1777 the then newly formed Boulton and Watt partnership built a steam pumping engine for Birmingham Canal Navigations. It was installed at the canal pumping station in Smethwick, and worked there until 1892. Six years later the engine was removed to the canal maintenance depot at Tipton, Staffordshire, where it has remained as a showpiece ever since. This historic engine is not, as has often been said, Watt's original engine, but it is almost certainly the oldest existing steam engine in the world and it is complete in every detail. Arrangements have now been made for the engine to be removed to the Museum of Science and Industry, Newhall Street, Birmingham, 3, where it will, in due course, be exhibited to the public. The engine has a bore of 20 in and a stroke of 5 ft 9 in.

# Letters to the Editor

## ENGINEERS' SALARIES

SIR, It is generally known that the Engineers' Guild has arranged to co-operate with the Royal Commission on Doctors' and Dentists' Remuneration in a joint survey of salaries and conditions of service in the engineering profession. This survey is now being undertaken and questionnaires were issued a fortnight ago to some 10,000 chartered civil, mechanical and electrical engineers.

It has just been brought to the attention of the Guild that the Institution of Professional Civil Servants has issued certain advice to its members on the question "whether they should or should not complete the questionnaire forms now being circulated at the instance of the Royal Commission," and since the general effect of this advice is clearly intended to discourage co-operation I hope you will allow me to reply to the points that have been made. These points can be summarised as follows:

1. The Institution has already declined to give evidence to the Commission because Civil Service salaries are "depressed salaries" and therefore "are not to be used in the consideration being given by the Royal Commission to salaries generally."
2. The Treasury has already supplied details of Civil Service salary scales.
3. The Guild "with its small membership of 4,600 has not the experience and knowledge" to enable it to carry out the task satisfactorily.

It cannot be too clearly emphasised that the object of the present survey is to obtain facts. In so far as the first two points do not cancel out one another, the answer to them is surely that particulars of salary scales do no more than indicate the steps in a ladder of promotion, without showing how the present staff are distributed on an age basis within the scales and so what are in fact the career prospects at the present time. In seeking to remove Civil Service salaries from the Commission's review, on the ground that they are "depressed salaries," the Institution is surely confusing fact and comment; the purpose of the inquiry is to secure comprehensive and reliable statistics about the conditions under which engineers are working to-day, in all fields of employment.

The third point made by the Institution is a more serious one because it implies that the size of the Guild *ipso facto* renders it incapable of carrying out its task satisfactorily. It is also stated that "the Institution has gone out of its way to avoid conflict with the Engineers' Guild" and this remark is likely to mislead some of those to whom it is addressed into thinking that the Institution has sought to co-operate with the Guild on this occasion, in order to mitigate some of its presumed difficulties. In fact, no approach has been made at any time, either officially or unofficially. On the other hand, both the Commission and the Guild have throughout enjoyed the help and guidance of the Social Survey Division of the Central Office of Information, the acknowledged expert adviser to the Government on statistical investigations, and the present survey is being carried out through its agency.

There are no grounds whatever for suggesting that the facts obtained from the survey will not be absolutely reliable, given only the support of those to whom the questionnaires have been sent, and I hope that what I have said will induce any of your readers who are included in the sample, and who may be undecided about their action, to complete and return their forms without delay. The Commission, the Guild and the Institution will all have the opportunity to comment on the facts when these have been ascertained.

Yours faithfully,
J. G. ORR, Secretary.

The Engineers' Guild.
19 May, 1958.

* * *

A letter on "Accelerated Curing Tests on Concrete" appears on p. 666.

**Automobile Engineering**

*By Gordon Wilkins*

# CENTRAL LONDON WITHOUT BUSES—PERMANENTLY?

In spite of street parking on a greater scale than ever before, London's traffic has been flowing with remarkable smoothness thanks to the absence of more than 8,000 buses which are confined to their garages by the strike, now in its third week. This revelation of the part which buses, by stopping, starting and interrupting the traffic stream, play in increasing London's traffic congestion has created demands for a reduction of services in the central area. The Greater London Area Council of the National Chamber of Trade has appealed to the Minister of Transport, and a question has been asked in Parliament. Passengers are now two millions a day fewer than they were in 1950, and the numbers are still falling. A rise of 20 per cent in short distance fares cost a 5 per cent loss of traffic.

Only two-thirds of the fleet is employed at off-peak periods, and it would seem that the rush hour crowds could be moved more quickly by using vehicles with a greater space for standing passengers. The unions are opposed to it and London Transport seems wedded to the idea of greater comfort in the hope of attracting passengers who now use their own vehicles—but rush-hour passengers would rather stand in a bus than be left standing in the rain.

A more realistic view seems to be shown in the new regulations issued by the Ministry of Transport to permit utility vehicles with up to 12 seats to be operated on rural bus services. It accepts lower standards of passenger comfort (but not of safety) in an effort to solve the economic problems of rural bus routes. Amendments have been made to permissible height and width of entrances and gangways, in the use of rear entrances, in ground clearance and the position of fuel fillers to permit existing vehicles to be adapted without undue expense.

If it sticks to its present policy on vehicle design and the standard of service, London Transport has little room for manoeuvre and seems condemned to rising fares and a falling total of passengers on the buses, which already have to finance the deficits of the Underground. Wages already represent about two-thirds of the cost of operating London Transport. The engineering side has been developed to a high pitch of efficiency and the detailed study which is given to operating economics was illustrated by the paper on fuel economics of buses which Mr. A. T. Wilford, Director of Research, London Transport Executive, read to the Institute of Petroleum earlier this year.

The bill for diesel fuel represents 13 per cent of the operating cost of the buses. In 1956 it reached £5·8 million, and in 1958 would probably have risen to £5·9 million but for the strike which is cutting consumption by 615,000 gallons a week. With diesel fuel at 3*s.* 10*d.* per gallon, £3·9 million goes in tax, leaving £2 million as the cost of the fuel. Average fuel consumption for the whole fleet is 9·5 m.p.g. It varies between 7·3 and 11·6 m.p.g. according to route, loading, speed and traffic conditions. The biggest single economy ever achieved was the switch to diesel engines nearly 30 years ago, which cut fuel consumption by nearly 50 per cent. Later, the use of direct fuel injection instead of indirect injection saved a further 10 per cent. Despite the use of higher compression ratios now possible, petrol engines are still not competitive. Introduction of the fluid coupling increased fuel consumption by 5 per cent, but this was more than regained by lower transmission maintenance, besides improving passenger comfort and reducing driver fatigue.

Weight reduction pays big dividends in fuel economy. The RM bus, which will replace the trolley buses during 1959, has a unit structure in light alloy, with plastic seat backs and thin, plus improved mechanical design, enables it to carry 64 passengers at the same fuel consumption as the current RT series shows with 56 passengers. The mileage run per gallon has been falling by 1 per cent per annum because of traffic congestion, raising the fuel bill by about £60,000 a year. A momentary stop from 25 m.p.h. costs 0·6*d.* but an unscheduled stop of 10 seconds costs 0·8*d.* because the bus must be accelerated to a higher speed to make up for it.

Weather is another factor that has an important effect on operating economics. A drop of 1° F in the mean temperature over the year adds about £20,000 to the fuel bill. Snow and rain also increase fuel consumption, the latter because the splashed rainwater cools the sump and increases oil viscosity. These effects are, however, masked by variations in traffic density.

Oil viscosity is highly important. A change from S.A.E. 30 lubricating oil to S.A.E. 20W cut fuel consumption by 3½ per cent and a later change to the use of S.A.E. 10W all the year round saved a further 2½ per cent. Thus changes in lubricating oil grade alone saved £350,000 a year. True, oil consumption rose by 15 per cent, but this was more than offset by longer life of engines and batteries. Another saving of 2 per cent (about £120,000 per annum) is hoped for from using oil of better lubricity in the worm drive rear axles. The effect here, however, is not primarily due to reduced viscosity. A castor base oil shows the most promise for this purpose.

Specific gravity of the diesel fuel is also important. The loss of calorific value per gallon outweighs the gain in calorific value in relation to weight. Tests over a year on sample buses showed that a change from fuel of 0·848 to 0·830 specific gravity increased consumption by 2 per cent. There is thus no hope of using fuel of 0·8 s.g. as widely used in the United States. The oil companies would like to sell more of the plentiful lighter distillates, and could presumably be induced to consider charging on a basis of calorific value, but so long as the government levies tax at the rate of 2*s.* 6*d.* per gallon there is little room for flexibility in this aspect of technical policy.

Confronted with militant trade unions, high taxation, the rapid growth of private transport and changing leisure habits, London Transport may well have to review their whole conception of passenger service for peak and off-peak travel in central London, the suburbs and the country areas. The further loss of traffic which always follows a strike will add urgency to the problem.

# A BABY AUSTIN HEALEY

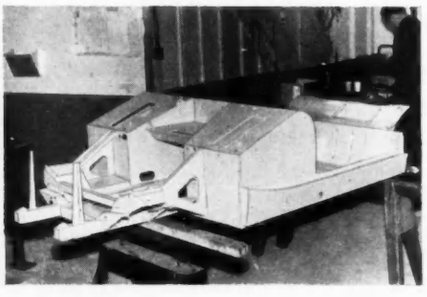
A new low-priced baby speed model called the Austin Healey Sprite brings sports car ownership within reach of a big new group of buyers who found existing models too expensive. Powered by a twin carburetter version of the 4-cylinder 948 cc engine used in the Morris Minor and Austin A35, the Sprite has a unit-body chassis structure in steel and several interesting mechanical features. It should reach speeds around 80 m.p.h. Front suspension, derived from that of the A35, is by wishbone and coil spring with an upper radius arm pivoting on a piston-type damper. Steering is by rack and pinion. The rear axle is carried on trailing arms with quarter elliptic springs and parallel-piston dampers.

Front wings, hood and grille lift upwards in one piece for easy access to the power unit, steering, front suspension and brakes. The car is so low built (only 49¾ in) that the headlamps could not comply with minimum height regulations for the United States if mounted in the wings and have therefore been planted on the bonnet, producing an odd and rather bug-eyed appearance. The original idea was to make them retractable but this was not possible at the price. The two separate front seats are plastic covered with foam rubber cushions and rubberised hair backrests. There is an open pocket in each door and space for a small amount of luggage in the tail. Instrumentation comprises speedometer with trip and total recorders, fuel gauge, thermometer, oil pressure gauge, warning lights for dynamo charge, headlamp high beam and flashing direction indicators. A tachometer is an optional extra.

The engine with 8·3 to 1 compression ratio and 2 SU carburetters delivers 42·5 b.h.p. at 5,000 r.p.m. and peak torque of 52 lb-ft at 3,300 r.p.m. Dry weight of the car is approximately 1,320 lb. Unladen power to weight ratio is thus 72 b.h.p. per ton. Fuel is fed by an A.C. mechanical pump from a 6 Imperial gallon rear tank. The engine has a full flow external fuel filter and coil ignition with centrifugal and vacuum control. The pressure cooling system uses pump, fan and thermostat.

Transmission is by single dry plate clutch of 6¼ in diameter, hydraulically operated by pendant pedal, and a four-speed gearbox with the top three ratios synchronised is controlled by a central lever. An open propeller shaft takes the drive to the hypoid rear axle. A 4·22 to 1 axle ratio with 5·20 × 13 tubeless tyres on four-stud perforated steel wheels gives 15·37 m.p.h. at 1,000 r.p.m. Brakes are hydraulic on all four wheels with drums 7 × 1¼ in and two leading shoes at the front.

**Front wings and bonnet lift as one unit.**



**The basic frame structure is pressed steel.**

**Plant and Equipment**

# ROTORCYCLE OVER LONDON

## *One-Man Folding Helicopter*

The one-man Rotorcycle, designed and constructed for the United States Marine Corps by Hiller Helicopters, Palo Alto, California, was recently demonstrated in London, as the accompanying illustrations reveal. It has also been demonstrated at a number of R.A.F. and R.N. air stations during May by the British sales agents, Helicopter Sales Limited, 14 Woodlands Parade, High Street, Watford, Herts.

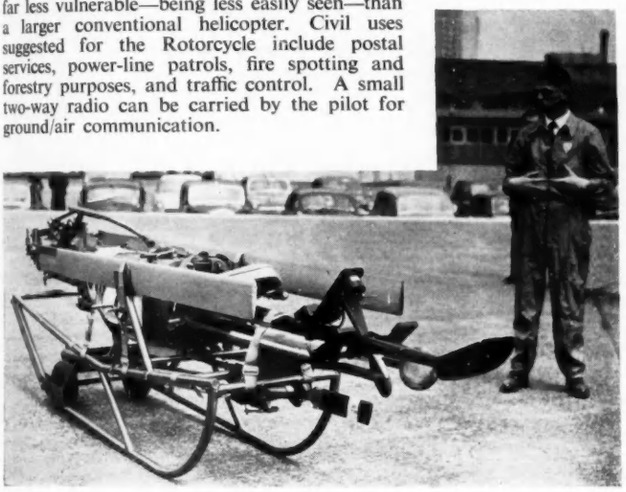
The Rotorcycle, mounted on a ground-handling pack, was driven to the South Bank helicopter station inside a station wagon, from which it was easily unloaded by three men. Removal of the little helicopter from its pack and erection was readily accomplished within three minutes; no tools are required for this purpose, all attachments being made by specially-designed quick-locking bolts.

Possible military applications of the Rotorcycle —which, when packed, is suitable for parachute dropping—are for infiltration, assault, rescue work, tank and artillery spotting, inspection and light wire-laying, courier work, and as an airborne communication station. It is said to be far less vulnerable—being less easily seen—than a larger conventional helicopter. Civil uses suggested for the Rotorcycle include postal services, power-line patrols, fire spotting and forestry purposes, and traffic control. A small two-way radio can be carried by the pilot for ground/air communication.

The Rotorcycle has a two-blade rotor with all-metal blades, 18·5 ft diameter, at right angles to which is a 5·2 ft diameter Rotormatic control rotor (a standard Hiller feature) which, the makers claim, gives increased stability and almost completely eliminates cyclic control forces. The controls are conventional, cyclic pitch being controlled through the upper control stick by the pilot's right hand, while collective pitch is controlled through the lever accessible to the pilot's left hand—this lever also embodying the throttle friction control. The pilot's feet operate directional control pedals. The Rotorcycle is powered by a 45 b.h.p. Nelson H63 two-stroke four-cylinder horizontally-opposed air-cooled engine, installed at the base of the pylon, the fuel tank being located above. The machine demonstrated in Britain had manual starting, but the production helicopter will be provided with an electric starter.

The outstanding feature of the Rotorcycle is its light weight—300 lb empty, and fully loaded, with pack, 556 lb—an exceptionally high gross-to-empty weight ratio for a helicopter. Its performance is lively: at an all-up weight of 496 lb (pilot only—no pack) it has a maximum rate of climb of 1,160 ft per min at sea level and a vertical rate of climb of 680 ft per min. The service ceiling is 13,200 ft, and the hovering ceiling, without ground effect, is 6,400 ft. It cruises at 52 m.p.h. and can put up a maximum speed of 70 m.p.h. The standard fuel tank holds 16 lb of fuel, but it is possible to carry an additional tank giving a total fuel load of 86 lb, on which a maximum range of 166 miles can be achieved.

If practical interest is developed in the Rotorcycle on this side of the Atlantic, it is probable that it will be produced under licence in Europe. It is expected to cost less than £4,000.



**(Left) The pilot surveys the folded Rotorcycle on its ground trolley.**

**(Right) Erected in less than 3 minutes, the Rotorcycle takes happily to the air.**

## MOBILE INFRA-RED PROJECTOR UNIT

There are numerous applications, particularly in paint stoving work, where it is preferable to bring the heating unit to the work, and the new mobile unit recently developed by Metropolitan-Vickers Limited, Trafford Park, Manchester, 17, will meet many such needs. It is particularly suitable for garage repair work, touching up on production lines, and for stoving or accelerating air-drying paints on large heavy objects such as castings. The unit should not be used for drying low flash-point finishes without taking suitable precautions.

The unit, consisting of a standard Metrovick projector with tubular sheathed elements, is mounted on a tripod fitted with rubber-tyred swivelling castors. It is designed to withstand the arduous conditions often experienced in service. While other sizes of projector are available, the equipment has been designed for the 24 in unit rated for 2 to 2·7 kW at standard single-phase voltages.

Local switching is provided by means of a three-heat switch giving control over one, two or three elements. The telescopic tube allows height adjustment from 36 in above ground to a maximum of 60 in with the projector horizontal while, at the same time, the projector can be swivelled through both horizontal and vertical planes to direct the heat to the desired area.

## LARGE ALUMINIUM WATER TANKS

Two light-alloy tanks, believed to be the largest tanks ever prefabricated for marine use, have been built by Windshields of Worcester Limited. They are made in ¼ in MG5 aluminium-alloy plate and extrusions supplied by James Booth and Company Limited, Birmingham.

The tanks are to hold fresh drinking water aboard two Caltex oil tankers being built in Belgium. The tanks are to be installed topsides and the use of the MG5 is therefore of great importance in saving superstructure weight. In addition, the water will store better, and traditional troubles due to scaling, rusting and tank-cleaning will be obviated. Similar light-alloy drinking water tanks may well become standard in future vessels throughout the world.

The first of the two tanks to be completed is 18 ft 0½ in by 13 ft 9¾ in by 7 ft 2¼ in and weighs approximately 4 tons. It left the factory on 2 May and proceeded with a police escort on a low-loading transporter to Tilbury for shipment. The second tank, 29 ft 6⅜ in by 12 ft 5⅜ in by 5 ft, weighing about 4 tons 3 cwt, was delivered in the same way on 14 May.

The tanks are Argonarc welded throughout, every weld having been subjected to exhaustive tests. Each tank is divided internally into two separate compartments holding 25 tons of drinking water, thus giving each ship storage for 50 tons of water in the new type of tank. The nominal capacity of the tanks is respectively 11,200 gal and 11,420 gal.

They are to be fitted into the bridge space of two new tankers each of 32,000 tons deadweight —Caltex Cardiff and Caltex Bristol—being built by S.A. Cockerill-Ougrée, Hoboken, Antwerp, Belgium, for Overseas Tankships (U.K.) Limited, an affiliate of the Caltex Group. Caltex Cardiff is to be delivered during the current year and Caltex Bristol is scheduled for mid-1959.

Windshields of Worcester Limited carried out welding and farbication of the tanks at their St. Johns Works, Bullring, Worcester.

## SCRATCH BRUSH

The TT welders' brush now being made by Rockweld Limited, Commerce Way, Croydon, Surrey, is a double-sided brush designed to cover most applications whether for welds or general corrosion cleaning. It consists of a single wooden stock, with shaped handle in hard beechwood. On one side it is filled with 40 tufts of tempered upright steel bristles in three rows, and on the opposite side with 39 tufts in three rows, but converging to a single line of densely-concentrated bristles.

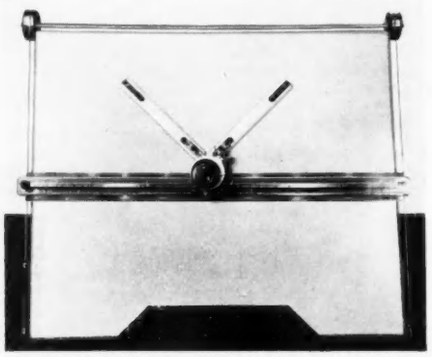
The upright bristle side is intended for all normal flat welds (before or after preparation) and the converging bristles for corner or fillet welds.

*Continuing* **Plant and Equipment**

## PARALLEL MOTION DRAFTING MACHINE

For accurate working many draughtsmen prefer the wire type parallel motion drafting machine, while others like the versatility of the machine with the drafting head.

The combination of these advantages has been achieved by the Angula Engineering Company Limited, Glaskin Mews, Pembury Road, London, E.5, with their parallel motion drafting machine.



**Accuracy and versatility are the features of the Angula parallel motion drafting machine.**

It can be fitted to any existing wire type parallel motion machine. The drafting head is mounted on a graduated alloy bar fitted to the straightedge and acting as a track. Each end of the straightedge is attached to the wire by a finger control knob facilitating angular movement of the straightedge on the board. This allows easy "line-up" with the drawing. Both transparent edges of the straightedge can still be used as in a parallel motion unit.

## DUST COLLECTOR VALVE

A new Dustex vacuum valve for dust collector hopper and bin discharges has been developed by Mancuna Engineering Limited, Windmill Lane, Denton, Manchester, and is shown in the illustration. No power is required, as it functions automatically and as there are no moving parts to wear out and cause leakage, no maintenance is required. The valve operates on the simple vacuum principle, the seal being maintained by the negative pressure within, which collapses the specially formed, flexible sleeve. The weight of collected material forces it through the sleeve at a constant rate of flow.

**Accumulated dust gravitates through the Neoprene sleeve against the closing force of the internal vacuum.**

The Neoprene rubber sleeve is resistant to most chemicals and will withstand temperatures of up to 350° F. For collecting material at higher temperatures, special sleeves are available.

# CLOSE-PACKED COMFORT

### *Lightweight "Economy" Aircraft Seats*

Shown in the accompanying illustration is a new type of "economy" aircraft seat now in production for British Overseas Airways Corporation for use in their "tourist" and "economy" class transatlantic services and is already installed in Britannia 312 airliners. The "economy" class service recently approved by the International Air Transport Association, means a reduction in seat pitch from the current 39-40 in in "tourist" configuration to 33-34 in. In most existing types of aircraft seating, the resulting "cramping" of the legs during a flight of many hours' duration would be well-nigh unbearable, and the new seats shown above are specially designed to overcome this problem. The seats are marketed by Aircraft Furnishing Limited, 41 Lonsdale Road, London, W.11—an association of three companies, E. G. Irwin and Partners Limited, design, development and consulting engineers; Latex Upholstery Limited, aircraft seating and furnishing specialists; and H. C. Shepherd and Company Limited, manufacturers of aircraft seats and components.

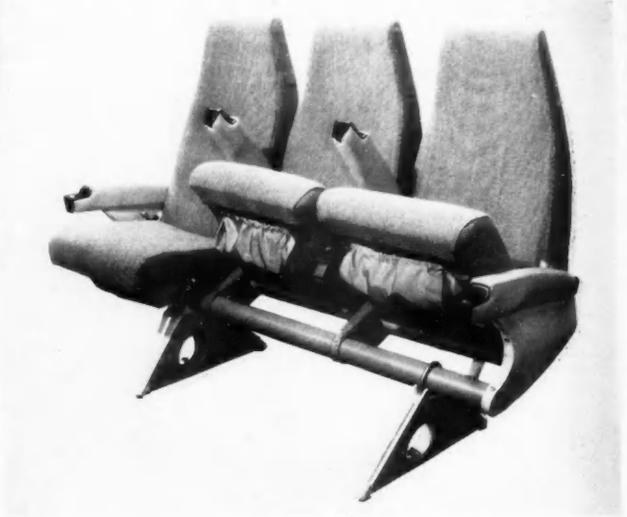
To meet the difficulties of close pitching, two new features have been built into the seats. The first is the high shin clearance of 14 to 15 in which allows the passenger to relax and stretch his legs freely. The other is the introduction, for the first time of a tip-up seat for aircraft passengers.

This feature has proved an outstanding advantage for passengers getting in and out of close-pitched seats, particularly those whose places are remote from the gangway. The seats also embody high standards of comfort, reclining backs, folding intermediate armrests, folding tables—stowed in the rear of the seat back—and a generous stowage pocket in the back of each seat place.

Later this year, a more advanced type of chair will go into production for British European Airways. They are to be fitted with hinging and folding legs to allow speedy conversion from passenger to freight carrying. The seats hinge about their floor-attachment points, and are quickly stowed *in situ* against the cabin wall. They will include the tip-up seat and will have a generous shin clearance of 15 in. The structure and mechanism is stressed for the official airworthiness requirement of 9*g* for forward and aft-facing conditions, and seats will be produced in double and triple units.

They will be installed in the BEA fleet of Viscounts 701 in a high-density layout of 60 seat places per aircraft. For this requirement, low forward-facing backs will be fitted which will be fixed by removing elements of the recline mechanism; a shelf-type table is stowed in the back of each seat. By a simple variation these same seats can be installed throughout the 800 series of Viscount aircraft. BEA will also use these seats for tourist accommodation in their Comet 4B aircraft and a proportion of them will be installed aft facing, fitted in this case with higher backs.

By substituting fixed legs (adjustable horizontally) these latest seats can be installed in any aircraft in any position taking into account the varying rail positions of different aircraft. The BEA-type triple seat weighs some 77 lb and the double seat 55 lb, which represents a saving possibly of the order of 30 per cent.



**On economy-class travel, seat pitch is restricted to 33-34 in. This new triple seat for BOAC has high shin clearance, allowing the passenger behind to stretch his legs.**

## AIR GAUGE

### *Portable Bench Stand Model*

An air gauge with magnifications up to 12,500 and a 5 in. clear reading scale is the latest addition to the range made by Teddington Industrial Equipment Limited, Sunbury-on-Thames. It is shown in the accompanying illustration.

Included in the unit are a built-in air filter, an air supply hose with quick release couplings, and an air supply pressure gauge. The range of magnification available on the instrument is from 1,250 to 12,500. It can be used with any of the range of air-gauging fixtures made by the firm.

**Bench model air gauge which gives magnifications from 1,250 up to 12,500.**

# Companies in the News

## Contractors' Golden Year

The year 1957 has been one of splendid achievement for British contracting and civil engineering firms. For most of them it has been a year of peak activity, particularly overseas. As the Minister of Works, Mr. Hugh Molson, pointed out when he addressed the Federation of Civil Engineering Contractors at their annual dinner last week, contracts worth several millions of pounds have been secured recently in the face of keen international competition. The past decade has been an era of rapid expansion for most firms and one of intense mechanisation. New machines and techniques have completely transformed contractors' methods.

Though there has been a fall in building activities and fewer large schemes are being undertaken because of capital restrictions, the road programme is gathering momentum, and the demand for energy ensures that the large firms will not be wanting for work. The annual reports of several of the biggest—Taylor Woodrow, Richard Costain and George Wimpey—suggest that there remains a great deal to be done. Mr. Frank Taylor, chairman of Taylor Woodrow, reported that his company had had the most successful year to date. Turnover amounted to £22¼ million, an increase of nearly 10 per cent in 1956, and trading profits were nearly £700,000 higher, at £1·9 million. Sir Richard Costain, chairman of Richard Costain Limited, also recorded a major increase in profits, by about £100,000 to £527,000. Their order book at the end of 1957 was higher than at the end of 1956 and amounted to £28 million. Half of the turnover in 1957 resulted from work overseas and the proportion is currently some 60 per cent. The importance of a wide geographical spread of activities in evening out pockets of local trade depression was emphasised by Sir Richard Costain, despite the fact that overseas " this work carries great risks and is highly skilled and specialised." George Wimpey's trading profit increased from £4·4 million to £4·7 million.

Prospects for the current year are best for those firms able to execute large contracts at home and overseas. Even in their case profitability is unlikely to rise very much. Should industrial activity fall substantially, however, Government action could easily and quickly produce more work, particularly road construction, than the industry would need to keep itself fully employed.

## Record Orders for Pumps

The annual statements of the two largest companies in the pump industry—G. and J. Weir Limited and Worthington-Simpson Limited—are encouraging documents. They have enjoyed a very high level of output in 1957 and orders have continued to come in at a level which promises that the current year will be another very busy and successful one. Both companies make a wide range of products outside the field of pumping plant. In the case of Weir, valves, steam-condensing equipment and even houses; in that of Worthington-Simpson, condensing, feed heating, evaporating and de-aerating plant as well as air compressors. In both cases order books tend to reflect general industrial activity, though in the case of the Weir group they are strongly influenced by the level of activity in the shipbuilding industry. In this field there was, according to The Hon. J. Kenneth Weir, chairman of the company, " some contraction in enquiries and demand due to duller conditions."

Sir Samuel R. Beale, chairman of Worthington-Simpson, told his shareholders that his company had experienced " a steadily increasing demand " for their established lines, and that incoming business for their standard products for the first quarter of this year was higher than the corresponding period of last year. An order worth £2 million was booked for a large new power station at Buenos Aires and is the largest in the company's history.

This trend of business is encouraging, but it should not be taken to be representative of the industry as a whole. Weir and Worthington are the giants in an industry of relatively small firms. Nonetheless, these results and developments do not suggest that a slump is around the corner.

## Vickers in Transition

The review of 1957 by the chairman of Vickers, Lord Knollys, indicates that major changes are taking place in the pattern of the group's activities. The greatest single influence is disarmament. When stated bluntly this almost invariably surprises, yet there is solid evidence in Lord Knollys' speech that the White Paper on armaments has begun to have an effect on industry. Nor is this wholly or even mainly due to the trend away from traditional means of fighting wars. It could in fact be argued that the technological advances of the past decade had, by creating a situation of nuclear stalemate in the world, replaced some considerable emphasis on conventional arms and ammunition. Vickers' trading shows that this has not been so.

The group's situation has changed in two major aspects, one peculiar to itself as one of the largest makers of weapons in the Western Hemisphere, and the other common to British industry. The first is the fall in Government purchasing of arms and in their financing of research and development connected with the defence programme. The second is the change in trading conditions, both in this country and in the rest of the western world, which took place during the year: according to Lord Knollys, " the sellers' market which had existed in most fields of industry since the end of the war had gradually faded out and changed conditions brought fiercer competition in almost every field."

Facts from the chairman's review illustrate well the changes in the field of armaments. For the first time in the Group's history since 1912 no new aircraft was under development for military service, although production of the Scimitar continued for the Royal Navy. In the shipyards, while submarines and small naval vessels continued to be built for the navies of the Commonwealth and for certain other friendly nations, only one major unit, the aircraft carrier Hermes, was still building at Barrow. Thus, after over half a century of preparing for war or for meeting threats of war, there comes a change deep and radical as changes in the long-established pattern of things must be. Vickers go forward as the suppliers of capital goods not as a stop gap between wars, but as a long-term policy.

## Trends in Steam Raising Plant

The turnover and trading profits of most makers of steam raising plant reached their highest figures ever in 1957: these results may even be bettered this year, but prospects are less bright. As in most sections of the engineering industry, production costs are rising and competition for new business increasing. In consequence, orders are being booked at prices which are less attractive and the profit margins secured in the fulfilment of individual contracts have been reduced. It is, however, the change in the pattern of demand which is causing concern. Despite the world's seemingly insatiable thirst for electric current, the demand for conventional steam raising plant has risen less than that for electricity. Water power is accounting for a rising proportion of new capacity and nuclear plants are likely to bring about an actual reduction in the number of orders for conventional steam raising plant during the next decade. Another factor is the rapid movement towards much larger units and super-critical pressures (some very telling figures were given in ENGINEERING for 9 May in regard to the new 550 MW Parsons turbo-generator sets).

These trends are the subject of interesting comments by the chairmen of two of the leading companies in the industry—Babcock and Wilcox Limited in the whole field of boiler and boiler-house plant, and Senior Economisers Limited in the much narrower field of steam economisers. The fact that Senior are without a stake in the development of atomic energy lends special weight to the remarks of their chairman, Mr. D. C. Lycett Green, concerning future demand for his company's products. Fewer orders are being placed for new conventional electricity power station boilers, he explained, and industrial projects involving steam raising plant have been curtailed by the credit squeeze. Exports have increased and may continue to do so. Yet the value of orders booked by Senior Economisers in 1957 was less than in 1956. Mr. Lycett Green attributes this to the fact that the " potential market was reduced."

Mr. W. Lionel Fraser of Babcocks underlines much of what has been said above. The position, he said, " is not made any easier by the trend towards massive single boiler units of higher technical rating involving a greater risk factor." Babcock, however, have gone a considerable way towards diversifying their interests. The manufacture of pressure vessels and the progress in the construction of nuclear plants are rising in importance in actual results and are likely to become the mainstay of the company's future activities. Senior Economisers, too, are taking steps to adapt themselves, mainly by entry into other fields. One wonders why, perhaps, much greater efforts have not been made abroad, wherever conventional steam raising methods are likely to continue to predominate, at any rate in the process industries.

## Growing Interest in Office Machinery

Reporting a high level of activity in the field of accounting and computing machinery, Colonel A. T. Maxwell, chairman of Powers-Samas Accounting Machines, told his company's shareholders of a growing interest in electronic and other high-speed products, as well as increasing demand for standard punched-card equipment. " The prospects of our industry," he said, "remain excellent for those who are prepared to keep abreast of the many developments which are taking place." Colonel Maxwell went on to say that he expected his company to complete this year the major transition establishing them fully in the electrical and electronic fields of book-keeping and data processing. Incoming orders for all the company's products are showing a " marked upsurge."

Announcing a trading profit in 1957 more than twice that of the previous year, Mr. A. K. Watson, chairman of I.B.M. United Kingdom Limited, also took a cheerful view of the demand for his company's products and confirmed Colonel Maxwell's statements. The data processing division of the company showed " an extremely satisfactory " increase in revenue and profit, and the order position " remains satisfactory." Apart from the electric typewriter division, where credit restrictions led to a fall of 20 per cent in sales, all I.B.M. activities in the United Kingdom showed an increase. Negotiations are in progress to secure official sanction to go ahead with an extension of 125,000 sq. ft to their Scottish factory, and a new factory (of 25,000 sq. ft) has been acquired in North London.

There is not much doubt that the industry to which Powers and I.B.M. belong falls in the " growth " category. But it is becoming highly competitive and the forthcoming struggle is likely to be decided in the research and development laboratories. No industry is more vitally affected by technical advance.

**Atomic Review**

# Second Look Forward

**1958** has already proved an exciting year in the application of nuclear energy. Since our first forward-looking symposium was published in Atomic Review on 3 January last, the thermonuclear assembly Zeta has made its first public appearance, and there has been considerable rethinking in the planning and organisation of atomic work generally. In particular, the proposal to build an advanced gas-cooled reactor (AGR) has been announced by Sir John Cockcroft. This reactor is a product of the metallurgist's skill, since its fuel elements are to be canned in the intractable element beryllium; the use of uranium oxide in conjunction with this material, in order to permit higher operating temperatures, is the reactor's main distinctive feature. The study of radioactive isotopes has continued, yielding new and valuable applications. Theoretical physics may have taken a significant step in the publication of an expression said to reconcile all known nuclear particles. Professor Werner Heisenberg, who has been mainly responsible for this development, is reported to have stated that his equation, if confirmed, would lead to a unified field theory, by which all aspects of physical science could be related. The following contributions are concerned with the use of nuclear radiation and radioactive isotopes, the metallurgy of reactors, thermonuclear fusion, and theoretical physics, with special reference to the future.

## USES OF ATOMIC RADIATION

*By Professor A. Charlesby*

The nuclear energy programme is of fundamental importance to the economy of this country since on its success depends the provision of adequate and cheaper power in forthcoming generations. In the reactor, particles of high energy arising from nuclear disintegration have this energy converted into heat and eventually into electrical power. More direct applications of this high-energy radiation are becoming increasingly available and include the use of radioactive fission products as tracers in chemical reactions, measuring devices, biology and for large-scale initiation of chemical reactions.

In the tracer application only small amounts of radioactive isotopes are used. When present even in extremely low concentrations, their presence can be detected by photographic or electronic means and they are therefore suitable for studying the flow pattern in chemical processes or in corrosion or wear. Many millions of pounds have already been saved by the use of radioactive isotopes and this sum will rapidly increase as new applications are found. Because of their great sensitivity, only small amounts of these radioactive isotopes are needed and this will eventually limit the market.

A range of radioactive isotopes is available giving radiations of varying penetration. Combined with suitable temperatures these may be used as thickness gauges, for measuring the level of liquids in opaque containers, in searching for oil and for radiographic examination of thick metal specimens. The small size of these sources, their long life and independence of power supplies make their use particularly advantageous in restricted space or for the routine examination of large production runs. They are currently used as a means of control in cigarette manufacturing machines and in monitoring the flow of liquids through pipe lines.

In the medical field, radioactive isotopes may be used not only in tracer applications but also in high intensity sources, for the treatment of cancer. In the past, cobalt 60 has been widely used for this purpose, but caesium 137, giving gamma radiation of lower penetration is now becoming available by separation of fission products.

The most recent developments in this field concern the use of very large quantities of fission products, whose radiation can be used to produce physical and chemical changes. Many materials when subjected to high intensities of atomic radiation become modified. This problem is of considerable importance in the design of nuclear reactors, where structural materials must not be seriously affected after a period of months or even years. In other compounds these changes may be beneficial and used commercially. As compared with the tracer applications the intensities involved are usually many millions of times greater, and can indeed be of the same order as the radiation intensity a few yards from an exploding atomic (uranium) bomb. With suitable precautions in the way of shielding, this violent treatment gives useful chemical changes without producing any permanent radioactivity. Examples of these applications are the sterilising of food-stuffs and pharmaceuticals, the production or modification of plastics, the initiation of certain chemical reactions and treatment of petroleum products.

In pharmaceutical or medical applications the articles are sealed in lightweight (such as plastics) containers and then subjected to a sufficient radiation dose to sterilise the contents. The cost of this process can be small and it may often be far simpler than many of the older techniques of sterilisation. The same approach is being made to the sterilisation of food-stuffs as an alternative to pre-cooking, but flavour changes have so far proved a serious obstacle to commercial exploitation. The use of low doses of radiation for disinfestation, and for improving the storage of potatoes is also being investigated. In the chemical field, a large range of reactions can be initiated by atomic radiation, but at present costs, few of these are commercially feasible. Research into further potential applications is being pursued very actively in such widely differing fields as petroleum refining, paint manufacture and preparation of pharmaceuticals.

In the plastics field, irradiation can be used to initiate polymerisation; the products are similar to those obtained by standard catalytic methods, but the better degree of control and the absence of temperature dependence offer great advantages. Of greater interest is the use of radiation to produce grafted and cross-linking polymers. Already several forms of cross-linking polyethylene are being sold on a commercial scale, the main advantage being increased temperature and creep resistance. Work on grafted polymers is still in the experimental stage but the direct combination of two (dissimilar) materials by means of radiation offers encouraging possibilities.

At present the cost of radioactive isotopes is still too high for most large-scale industrial applications, while the supply is limited. Alternative sources are electrical machines, capable of providing electron beams of several million volts. These two very distinct kinds of source nevertheless produce similar forms of radiation, but the power output from the electrical machines is considerably higher than the radioactive isotopes at present available. By using beams of electrons these accelerators provide intense beams of radiation of relatively low penetration. For higher penetrations or low intensity sources, radioactive isotopes have considerable advantages. At present, high-power electrical sources are available but no comparable sources of fission products. The extension of the nuclear energy programme will undoubtedly increase their availability and lower their cost and we can then expect to see considerable competition between these two very different but complementary sources of radiation. At this stage it is inadvisable to associate the use of atomic radiation too closely with either the nuclear power or the electrical industries.

## METALLURGY AND FUELS

*By L. M. Wyatt*

Most of the early piles were fuelled with uranium metal. Nuclear considerations demanded high density and purity in natural-uranium fuelled graphite-moderated or light-water cooled reactors. Under these conditions aluminium cans were a natural choice.

Pure uranium metal, however, reacts strongly with air, carbon dioxide, hydrogen and water at reactor temperatures, distorts at low temperatures and swells at high temperatures under irradiation. Its phase transition at 660° C sets a ceiling on its operating temperature, and it alloys with aluminium at temperatures over 175° C.

The development of magnesium as a canning material with excellent nuclear properties, inertness to uranium and ability to accommodate swelling has extended the application of substantially pure uranium to economic power reactors, and has set a standard of economy not easy to surpass, but its potential development is limited.

Irradiation effects on uranium metal may be largely eliminated by alloying with 14 per cent molybdenum. Where nuclear and coolant compatibility considerations permit, as in the sodium-cooled fast reactor, such alloys have considerable potential, and may also permit the incorporation of plutonium as fuel.

For economic thermal reactors the need for increased rating, burn-up and operating temperatures has focused attention on the use of oxides which were originally only considered suitable for very low power reactors such as Gleep. The use of oxide fuel, which may consist of uranium oxide ($UO_2$), uranium oxide mixed with plutonium oxide ($UO_2$, $PuO_2$) or thorium oxide mixed with uranium oxide ($ThO_2$, $UO_2$), originated, in the United States mainly because of the unsuitability of uranium metal for use with a high-pressure water coolant, but its advantages of dimensional stability and compatibility may well lead to its use in the United Kingdom's gas-cooled reactors.

It is not without disadvantages. Although intrinsically cheap, it has so far proved expensive to fabricate compared with uranium metal, its tendency to evolve fission-product gases under irradiation increases with temperature, and its brittleness demands a rigid can. Suitable canning materials are steel with, as alternatives, beryllium for gas-cooled, and zirconium for water-cooled reactors. Beryllium and zirconium both have advantages in nuclear properties as compared with steel, but zirconium demands great care in production and fabrication to retain its excellent resistance to water corrosion, and beryllium requires advanced techniques in fabrication, to overcome its lack of ductility, which is reduced further by neutron irradiation.

Reactor development must, therefore, take account both of the possible improvements in technology of the newer metals to reduce cost and improve performance, and of reduction in section of steel cans to reduce the extra enrichment.

In the United States, fissile material is relatively cheap and abundant, and an increase in enrichment of a fuel (which must in any case be considerably enriched because of the characteristics of water-cooled reactors) is not a serious matter. In the United Kingdom fissile material is more expensive and less abundant, and the relative increase in cost resulting from the change from a near natural uranium cycle to a moderate enrichment is much greater. Fortunately unlike the enrichment of the fuel the basic design of a

reactor is affected only to a small extent by these alternative canning materials, and reactor development is not therefore seriously affected.

The permissible ratings of solid oxide fuels are limited by thermal conductivity if impossibly small sections are to be avoided. If future development demands increased ratings with conventional fuel elements, the answer may lie in the use of carbides which have superior thermal conductivity to oxides. They are, however, more difficult and expensive to fabricate, and are attacked by water and carbon dioxide. They would appear highly suited for sodium-cooled reactors, but quite unsuitable for water-cooled; and for gas-cooled the different properties of the suitable coolants (hydrogen or helium) would demand radical changes in design.

On the time scale in which such changes in design are possible it may prove more advantageous to make the further step of combining moderator and fuel and so obtaining high rating, by means of extended surface, long burn-up by dilution, and incidentally high operating temperature, by incorporating the fuel in a matrix of graphite, or beryllia. Still further in the future lie the fluid fuels. These have attractions, but whether the development problems associated with them will be solved before fission is superseded by fusion cannot be predicted.

If economic propulsion reactors are developed it would appear that their fuels will be of similar types to those described for the economic power reactors but of higher enrichment. For military applications, where reliability and compactness outweigh economic factors, the pressurised-water reactor operating on pure fissile material has so far been used exclusively. Here again there is a choice between steel and zirconium. In the case of the submarine, where everything must be sacrificed for compactness, use is made of uranium zirconium fuel with zircalloy sheaths. The Army Package Power Reactor (APPR) on the other hand, uses a dispersion of uranium oxide in steel, with stainless-steel sheathing material. This latter fuel is more expensive in fissile material, and the core occupies slightly more space but uses cheaper materials and costs less to fabricate.

## FUSION POWER

### *By Dr. A. Gibson*

The recent announcement that Zeta, Harwell's thermonuclear experiment, has achieved considerable success must have caused many to speculate on the meaning of the event. Viewed optimistically Zeta opens up the road to the exploitation of a limitless and inexpensive fuel supply. It is natural to ask when will energy produced in this way be available and will it eventually compete with energy from other sources?

Zeta, and similar devices, are the only guides we have to the answers to these questions, and since Zeta will only be a toy when compared to a power producing reactor, it is not surprising that the answers are not known with any precision. The cost of the new energy will depend on the capital cost of the final installation and on its overall efficiency; estimates of this cost vary from the extremely pessimistic to those which suggest that it will, in fact, compare with the cost of energy from conventional sources. Estimates of the time to evolve a fusion reactor which generates electricity, range from ten to fifty years. Zeta has overcome what has previously been regarded as the major obstacle to progress—the instability of the discharge. If the remaining difficulties can be quickly overcome then ten years may well prove to be the correct estimate. If, on the other hand, such difficulties as that of heating the gas above 5 million °K, or of providing suitable wall materials for the torus, should prove intractable fifty years may well be nearer the mark.

It is possible, however, in view of the results from Zeta, to see in what direction future progress will take place. Before the operation of Zeta several alternative systems seemed to have a better chance of eventually leading to a power reactor. Competing systems seemed, theoretically, to avoid two of the major difficulties predicted for the Zeta system. The first difficulty was that a considerable degree of instability would be unavoidable, and that this would lead to cooling of the fuel gas by the containing walls, contamination of the fuel by vaporised wall material, and severe damage to the walls. The second difficulty was that, due to the rapid decrease in discharge resistance with temperature, the resistive heating process, which it was assumed would be operative in Zeta, seemed likely to be ineffective above temperatures of 1 million °K. It was suggested that beyond this temperature energy would be given to the electrons but not transferred from them to the ions. These difficulties were to be overcome in other systems at the expense of a considerable increase in engineering complication, or by the use of dissipative processes which would reduce the efficiency of the final system.

The most important conclusion to be drawn from the Zeta experiment is that neither of these objections has materialised in practice. Firstly, an acceptable degree of stability has certainly been achieved. It is now realised that this is because the stability requirements for large toruses, such as Zeta, are easier to satisfy in practice than are those for the small toruses in which earlier measurements were made. Secondly, the fuel ions in Zeta have reached temperatures of 3 million °K in times of about one millisecond, which is about one-quarter the time suggested by the most optimistic calculations based on the resistive mechanism. This suggests that an unknown mechanism is at work heating the ions comparatively rapidly. Many suggestions have been made as to its nature, some suggest that oscillations in the plasma transfer energy from the electrons to the ions, while others maintain that the adiabatic heating of the gas by the pinch effect is more important than is usually thought to be the case. These mechanisms have in common the property that they are not adversely affected by high plasma temperatures.

It seems then that there is no immediate obstacle to producing hotter discharges for longer times in devices like Zeta, and an attempt to do this will certainly be the next step in this country.

It is possible to obtain some ides of the scaling laws applicable to stable pinched systems, by considering the three systems for which results have been published—Zeta, Sceptre III, and Perhapsatron S3. Temperatures of 300 million °K are likely to be needed to produce useful power from the deuterium-deuterium (D-D) reaction, and it can be shown that this will require currents of the order of 10 million amperes, compared to 200,000 amperes in Zeta. Power from a deuterium-tritium (D-T) fuel mixture would only require about 1 million amperes but of course tritium is a difficult material to make. Future reactors are likely to be larger in size than Zeta because the technical problems of achieving stability are less severe, and because the power loading on the walls will be less in large vessels.

In the near future, possibly at the Geneva Conference, we can hope to hear something of other experimental fusion reactor systems.

In the more distant future we can look forward to power reactors using deuterium gas to produce electrical power directly, without the aid of heat exchangers and turbines. These reactors will not produce the radioactive by-products that are inevitable with fusion reactors.

*(A description of Zeta was published in ENGINEERING, 31 January, '58, p. 134. Dr. Gibson's contribution was received before the most recent announcements by the UKAEA concerning the Zeta experiments and the subject of our note on the following page.)*

## *Contributors*

Each contributor to this symposium has been actively engaged in the work on which he writes. Professor A. Charlesby is an authority of international reputation in the field of radioactive isotopes. After leaving the Atomic Energy Research Establishment at Harwell, he joined Tube Investments Limited, where he was in charge of radiation research, and was subsequently appointed Professor of Nuclear Physics at the Royal Military College of Science. Mr. L. M. Wyatt, who is Head of the Metallurgy Section, United Kingdom Atomic Energy Authority Industrial Group Headquarters, Risley, has been intimately concerned with the development of materials for fuel elements, including those for certain advanced kinds of reactor. Dr. A. Gibson is a scientific officer on the staff of the Atomic Energy Research Establishment, and is a member of the physics research group working on the thermonuclear project. Mr. A. Ashmore, who is a lecturer in physics at the University of Liverpool, has been engaged on research in medium high energy nuclear physics using the 156 in synchrocyclotron of the Nuclear Physics Research Laboratory, University of Liverpool. Recently, Mr. Ashmore, with three colleagues, has completed a study of the cold, or muon-catalysed, fusion process discovered by Dr. L. Alvarez at the University of California (see Atomic Review, 4 April '58).

## THEORETICAL PHYSICS

### *By A. Ashmore*

In the last year considerable progress has been made with the theoretical description of the interaction between two nucleons (neutrons and protons). It now seems that it may be possible to describe this interaction by means of a relatively simple potential. One such potential has been developed by Professor Marshak and Dr. Signell of the University of Rochester. Their potential predicts with remarkable accuracy the results of proton-proton and neutron-proton scattering experiments between 20 MeV and 150 MeV energy of the bombarding particle. These experiments include not only straightforward cross-section measurements in a single scattering, but also polarisation effects in double and triple scattering experiments. A single scattering in general produces in any direction a polarised beam of nucleons with their spins on the average pointing in a definite direction perpendicular to the scattering plane. This polarisation can be measured by a second scattering in the same plane, since a polarised beam has different cross sections for scattering at the same angle to the left and to the right. Further information of a similar kind can be obtained from triple scattering experiments. The improvements in experimental technique which have made such experiments possible have been an important factor in the progress that has been made.

A series of experiments of this type have been carried out at the University of California for proton-proton scattering at 310 MeV. The results are a stringent test of the potentials. They are not in very good agreement with the predictions of Marshak and Signell. Rather better agreement is obtained by a similar potential developed by Drs. Gammel and Thaler of the University of California.

The form of the potential is most easily described in the case of that due to Gammel and Thaler. It bears some resemblance to that between the atoms in a diatomic molecule. There is an infinite repulsive core into which the nucleons cannot penetrate, at a separation of about 0·4 by $10^{-13}$ cm. Outside this core the force between the two nucleons is attractive. In addition to the normal central force there is a tensor force and a spin orbit force. A familiar example of a tensor force is that between two bar magnets. The spin orbit force is due to the coupling between the orbital motion of the nucleons and their spinning motion. It is these non-central forces which cause the polarisation effects observed in the scattering experiments. The range of the forces is about $10^{-13}$ cm for the

## *Continuing* Atomic Review

central and tensor forces, and about 4 by $10^{-13}$ cm for the spin orbit force. Although these potentials are by no means entirely satisfactory they represent an important step forward. Attempts are also being made by theoretical nuclear physicists to see whether the properties of a complex nucleus, containing many protons and neutrons, can be explained in terms of the interaction between two nucleons. This approach to the many-body problem was originally suggested by Dr. Brueckner of the University of Pennsylvania. It now seems that it may be possible if the interaction between two nucleons is slightly adjusted to allow for the effect of other neighbouring nucleons.

The last year has seen consolidation but not confirmation of the two-component neutrino theory suggested independently by Lee and Yang in the United States, Landau in the U.S.S.R., and Salam in this country, to explain the non-conservation of parity in the weak interactions of elementary particles. It is important to realise that parity non-conservation has only been found in weak interactions, which include the decay of the hyperons, K-mesons, pions and muons, and the $\beta$-decay of the nucleon. In strong interactions, such as the production and scattering of nucleons, pions, K-mesons and hyperons and in electromagnetic interactions, it has been recently verified that effects due to non-conservation of parity are less than $10^{-7}$ in magnitude relative to effects in which parity is conserved.

The parity operation consists of replacing every radius vector $\mathbf{r}$ by $-\mathbf{r}$. If parity is conserved this process should produce no change in physical laws. Parity non-conservation is detected by such effects as the longitudinal polarisation of muons produced in pion decay, and of electrons produced in muon decay or in $\beta$-decay of the nucleon. Longitudinal polarisation means that the axial vector representing the spin of the particle is aligned along or against its direction of motion. The parity operation would reverse the direction of motion but not the spin, which is an angular motion. It would thus change the direction of the longitudinal polarisation relative to the direction of motion and so alter a physical law. Existence of the longitudinal polarisation in decays of this kind is a definite indication that parity is not conserved.

In the two component theory it is assumed that the neutrino is a left-handed particle with its spin vector in the opposite direction to its direction of motion, and that the antineutrino is a right-handed particle. It is also assumed that it is the neutrino which is emitted with the positive muon in pion decay and with the positive electron in $\beta$-decay; whereas the antineutrino is emitted with the negative muon in pion decay and with the negative electron in $\beta$-decay. In decays of muons of either sign both a neutrino and antineutrino are emitted along with the electron. This theory shows in a very simple way that the muons from pions decaying at rest will be left-handed if they are positive and right-handed if they are negative. It also shows that the electrons from muon decay will be right-handed if they are positive and left-handed if they are negative. These predictions have been confirmed for the electrons by Dr. Holt and his group at the University of Liverpool but remain to be confirmed for the muons.

Theoretical physics would indeed be shaken if it were found that physical systems were not invariant under the combined operation of parity P, charge conjugation C, and time reversal T. The charge conjugation operator C changes particles into antiparticles and vice versa; the time reversal operator T merely replaces $t$ by $-t$. It is easily seen that the two component theory is contrary to invariance under P and also under C. The former reverses directions of motions but not spins and so produces a right-handed neutrino and a left-handed antineutrino, neither of which is allowed. The latter has the same result since neither directions of motion nor spins are affected but the neutrino becomes the antineutrino and vice versa. Invariance remains under the combined operation PC in either order, and also under the time reversal operation which reverses both directions of motion and spins. Thus this theory still preserves invariance under PCT.

## *Notes and News*

### Fusion In Zeta Not Thermonuclear

In the past few months the heating processes occurring in Zeta have been under study at Harwell. It appears that in addition to the heating of ions by electron collision—the expected process—some proportion of the deuterons are reaching high energies by non-thermal processes. Because it is the high energy ions that produce neutrons observed during the high-current discharge, it appears that true thermonuclear reactions have not occurred in Zeta to any great extent.

Speaking at the British Electrical Conference (held in Brussels on 16, 17 May), Sir John Cockcroft said that the energetic nuclei appeared to have been accelerated by the impressed electric field. The applied field around the ring amounted to about 1½ kV and some deuterons might circle round the ring 10 times, being thus accelerated through 15 kV. Previously it had not been thought that the deuterons could travel such a distance without collision with other particles in the tube. Sir John was reading a paper entitled " Nuclear Energy—the Power of the Future."

Zeta was designed to produce temperatures of about a million degrees centigrade in a gas held well away from the walls of the containing vessel. This it more than achieved. Spectroscopic measurements showed ion temperatures of up to five million degrees centigrade; and the gas was well isolated from the walls for about three milliseconds. The total number of neutrons emitted from fusion reactions was small and technical difficulties severely limited the measurements which could be made on them. In fact, it was pointed out when the Zeta results were first published (ENGRG., 31 Jan. '58, p. 136) that " To identify a thermonuclear process it is necessary to show that random collisions in the gas between deuterium ions are responsible for the nuclear reactions. In principle, this can be done by calculating the velocity distribution of the reacting deuterium ions from an exact determination of both the energy and direction of emission of the neutrons. The neutron flux so far obtained is insufficient to attain the desired accuracy of measurement."

Some months ago a new experiment was devised to try to obtain further information on the subject. A high-pressure Wilson cloud chamber was put on the end of a collimator and the neutrons coming from the gas plasma in the centre of Zeta were examined. In the cloud chamber the neutrons produced protons whose energies could be determined. It was found that when the current through Zeta was reversed, the maximum direction for the emission of neutrons was also reversed. This showed that, in the main, the neutrons were being given off from the gas in the general direction of travel of the ions. The interpretation of these results suggested that the neutrons were being emitted when high speed deuterons collided with almost stationary ones. The number of very fast deuterons was found to be a very small fraction of the total number present. During the time that the hot gas is held together in the centre of the tube, the fast deuterium atoms have insufficient time to make enough collisions with other deuterons to share their energy: they have not reached thermal equilibrium. Thus the fusion reactions obtained cannot be described as thermonuclear.

However the Zeta results are still important. A random distribution of energy between the deuterons in the hot gas is thought to be ultimately necessary for a fusion reactor to be efficient. Before this stage can be approached, the hot gas must be held together about 100 times as long as has been done so far. It would appear that the equipartition of energy between the deuterons would be reached in a very much shorter time than this, since the electric field to maintain the current is very much smaller than that required initially. The work with Zeta reported in January gave confidence that higher temperatures and longer times of isolation can be achieved.

At the end of his paper, Sir John explained that preparations were being made to feed ten times as much energy into Zeta. Containment times of one tenth of a second were aimed at. Preparations were also being made to build Zeta 2, in which the energy would be increased by a further factor of 10. " We think this is an exciting programme," said Sir John, " . . . but we do not think we will have a fusion station for at least 20 years."

### New Atomic Safety Committee

Sir Douglas Veale, C.B.E., until recently Registrar at Oxford University, has accepted the chairmanship of a committee set up by the United Kingdom Atomic Energy Authority to advise on training in radiological protection. The committee includes: Sir Ernest Rock Carling, consultant adviser to the Ministry of Health, the Atomic Energy Authority and the Home Office; Professor W. V. Mayneord, director of Physics Department, Institute of Cancer Research, Royal Marsden Hospital; and Professor B. W. Windeyer, Professor of Radiology (Therapeutic), University of London.

This committee will advise the Authority on the training and provision of specialist health and safety staff, not only for the Authority's own purposes but also to meet the needs of the nation as a whole.

### Hulton Achievement Award

The Zeta team at AERE Harwell are the first recipients of the Hulton Achievement Award. The members of the team sharing the award—which consists of a silver trophy, an inscribed silver medal, and a cheque for £1,000—were, Dr. R. Bickerton, Mr. E. P. Butt, Mr. R. Carruthers, Dr. A. Dellis, Mr. D. W. Fry, Dr. A. Gibson, Mr. G. Harding, Mr. D. J. Lees, Mr. R. W. P. McWhirter, Mr. J. T. D. Mitchell, Mr. R. S. Pease, Dr. S. A. Ramsden, Mr. R. Taylor, Dr. W. Thompson, Dr. P. C. Thonemann, and Mr. S. Ward. The presentation was made by Sir Edward Hulton to Dr. Thonemann, head of the Zeta research team.

### Delay in Nuclear Power Plans

The recent White Paper " Capital Investment in the Coal, Gas and Electricity Industries " (Cmd. 415, April 1958, Stationery Office, 6*d*.) draws attention to a delay of one year in the completion of the nuclear power programme as a result of revised capital investment plans.

For electricity generation, the approved level of expenditure on nuclear power stations for 1958-59 is £37 million as compared with £21 million for 1957-58 and includes expenditure on continuing work at Bradwell and Berkeley, and the beginning of work at Hinkley Point.

### More Power from EBWR

It is reported that the Experimental Boiling Water Reactor (EBWR) at the Argonne National Laboratory of the Atomic Energy Commission, Lemont, Illinois, was successfully operated at a power level of 62 MW (thermal) in recent experiments. This operating level is more than triple the original design operating level of 20 MW. In December, 1957, the EBWR was operated in experiments at 50 MW (thermal).

Such an increase would raise the amount, and reduce the unit cost of electricity produced by the plant, if increased generating capacity were installed.

**The Human Element**

# *Entry Through the Back Door*

A considerable amount of resentment has been stirred up by the number of ex-officers getting into the executive ranks of the Civil Service without competitive examination. It was the subject of a resolution at the annual conference of the Society of Civil Servants at Scarborough last week. A unanimous resolution drew the attention of the official side to this practice.

The situation is an unfortunate one and could have been handled with greater tact than seems to have been forthcoming. Established civil servants are bound to feel that an intake of such recruits is going to reduce the opportunities of promotion for their members and also that some take the jobs only to eke out pensions. The cream of the fighting services will not find great satisfaction in the executive ranks of the Civil Service.

It would have been better to have brought the problem into the open and let the union officially consider the officers' point of view. There is a case for admitting personnel from other branches of the public services without competitive examination. There is also a case for not swamping particular grades with outsiders. Tact in such circumstances is no more than good management and good human relations. This is the sort of problem which could have been foreseen and a potential irritant in the public service removed before it could develop.

## *Wage-Earning Prisoners*

By the spring of 1959 it is hoped to bring into operation a scheme whereby prisoners serving long sentences will be able to have six months in a hostel, work for private concerns, earn a wage and thus be able to pay something towards their keep and save against the day of their release. Announcing this when addressing the National Association of Prison Visitors in London last week, Mr. Butler as Home Secretary said that prisoners would be chosen with care.

At present not many prisoners are gainfully employed. Some make uniforms for the Post Office, or do cobbling work, some make bricks and baskets and a few are on light engineering work. The new scheme will have the merit that it will get men away from the prison environment at a time when the prisons are badly overcrowded and it will also help to restore self-respect.

Two among other problems remain, however. First of all there is the position of the trade unions to consider if there is anything less than overfull employment in the country. They are not likely to be enthusiastic about dilution of the labour force by prisoners. Second, many younger offenders in prison are there not because of poverty (sometimes quite the reverse, for they have had enough money to get into trouble) but because of poor home environment. This basic problem remains to be seriously tackled—if indeed it can be by the authorities.

## *Pensions Survey*

A survey has been made of existing pensions schemes, the findings being published under the title *Occupational Pension Schemes* (H.M.S.O., 2*s*.) There has been a lack of statistics about pensions schemes run by private organisations up to the present. The new survey fills this gap to some extent. In addition, of course, it fulfils the rather less innocent function of providing a factual background for any future pension scheme on a national basis.

The survey was based on material drawn from two sources. These comprised a questionnaire to selected employers and an examination of the rules of schemes submitted to the Inland Revenue. The main points brought out by the study were as follows. There are about 8¾ million persons covered by pensions schemes, of which 7 million are men (half the male employed population). There are over one million pensioners. In 1956 there was about £246 million paid into private schemes (by employers and employed). The corresponding figure for the public services and nationalised industries was about £221 million. A significant proportion of the schemes are non-contributory for the employee—a fact already known. Few members are entitled to a lump sum on retirement. On withdrawal an employee usually receives a lump sum equivalent to the sum he himself has paid.

## *Three Per Cent*

The Government take a most favourable view of the railway wage dispute settlement. In the Commons last week Mr. Watkinson, Minister of Transport, said that it was " strictly within the principles of the Government's anti-inflationary policy." The whole of the cost of the increase is being found by the Transport Commission from economies to be made in operating costs. Passenger services will be cut wherever they are uneconomic and the measures to increase the efficiency of the freight services are being intensified. The political and social consequences of such cuts will presumably be left to take their course, at least until the public squeal loud enough. At present all is well: to quote Mr. Watkinson once again, " if all employers follow this settlement and grant no more than a three per cent increase to be found within their own resources, then we shall have beaten inflation in the right way."

Some of the Government's critics have been heard to remark that more money will be paid out to the Commission to finance the railway modernisation plan. On this one may quote a recent speech by Lord Chandos who said last week that labour would in fact get " dearer and dearer," whether we liked it or not. Labour had " the right to demand " less effort for a given output and better working conditions. Lord Chandos does not view this as a matter for regret or despondency but as an incentive to increase productivity and mechanisation. To sacrifice productivity, he said, to the delusive and unattainable objective of a wage freeze would show a complete inability to learn.

The fact remains that the rail wage award has set a pattern and a rate unlikely to be greatly exceeded elsewhere. Wages are thus likely to increase less than for several years and less than wages in Germany and the United States.

## *No Chink Seen*

Mr. Macleod, Minister of Labour, introduced an unhappy sentence in a speech he made last week in review of the London bus strike situation. He would be ready to step in, he said, as soon as he saw " a single chink of light." In the prevailing mood among labour this was interpreted as waiting for a breakdown in the strikers' resistance.

The settlement of the railway wage dispute has now left the unions with London as their main field of operations against what they have labelled as Government meddling with industrial affairs designed to weaken the bargaining power of the movement. Mr. Cousins was quick to retort with a warning that the Minister of Labour should take care lest he should see " a conflagration and not a chink of light." A meeting of the two parties has been called by Sir Wilfred Neden, Chief Industrial Commissioner, as we go to press. The likelihood of a settlement is remote, despite the strong financial incentives of both sides to come to terms. At present the prospects would seem to be an extension of the strike, since the unions cannot precipitate a crisis with the buses only. Much depends of course on the view the unions have taken of the three per cent awards to the railway workers. In view of the threatening industrial storm they might conceivably accept a similar settlement.

## *Arbitration Request*

American car workers are fighting to improve their lot in conditions worse than at any time since near-complete collapse in car demand took place in 1938. Unemployment in Detroit is high and the prospects of a recovery not even a talking point. The tactics of the United Automobile Workers' Union in such unfavourable circumstances are therefore known to both sides of the motor industry in Britain, which so far has experienced nothing of the United States slump. Mr. Walter Reuther, president of the UAWU, has suggested that negotiations with United States motor car companies be submitted to arbitration. He proposed the setting up of three five-men panels consisting of nationally known economists, two selected by the Union, two by the companies and one impartial. All economic data connected with the bargaining would be submitted to the panels and the arbitrators' findings would be binding. The panels, each dealing with a major company's affairs—General Motors, Ford Motor and Chrysler Corporation—would be asked to fix the total amount the companies could pay without having to raise car prices.

General Motors rejected the proposal at once; Ford and Chrysler were expected to follow suit. The companies appear to be determined not to open their books to union negotiators and favour an extension for two years of existing contracts, with provision for an annual productivity pay increase. In this respect, also, the United States motor industry is giving an interesting lead. Mr. Reuther proposed—as an interim measure, while the arbitrating machinery was being established—an annual increase in wage levels or productivity increase award of 6 cents per hour or 2½ per cent, whichever was the greater.

## *Profit-Sharing Basis*

An important change has been made in the way in which the employees' profit-sharing figures are to be calculated by Imperial Chemical Industries. Until now, the percentage paid to employees in ordinary stock of the company has been calculated as the difference between the ordinary dividend paid and 5 per cent, so that if the ordinary shareholders got 12 per cent, the employees received 7 per cent of their wages as bonus. Two disadvantages have appeared.

In the first place the employees can be adversely affected when a change in the capital structure of the company changes the rate of dividend paid. This has now happened with the issue by the company of a scrip bonus to shareholders which could have the result of considerably reducing the percentage paid to shareholders on issued capital without changing the amount in money. But it would be the percentage change which would affect the employees' participation. The second disadvantage of the present method is that an increase in the wages bill increases the burden of the bonus on the company.

A new method of calculation has been introduced which fixes the employees' share as a percentage of the total amount of dividend and interest paid in the year. In other words, it ties the employees' bonus to the money distribution to shareholders and hence to the profit and loss account rather than either to the capital structure or wage costs.

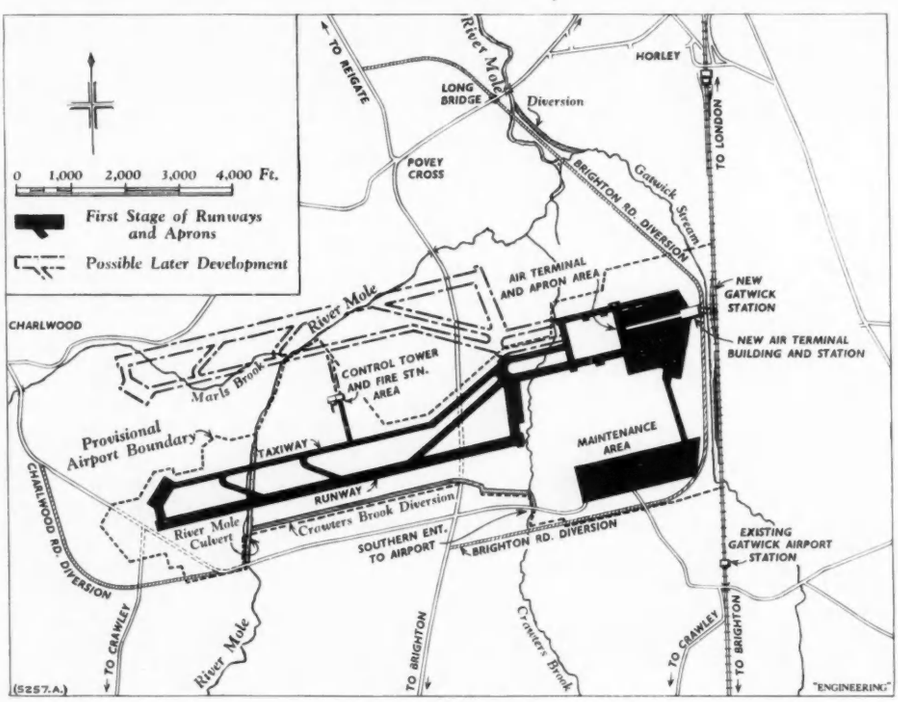
# THE NEW GATWICK AIRPORT

## *Where Road, Rail and Air Services Meet*

Gatwick Airport, situated 20 miles south of London and built to relieve the pressure on London Airport, is among the world's first communication centres where road, rail and air transport meet at one point. The main terminal building of the Airport straddles a trunk road—the A23—and is adjacent to a railway—the Southern Region's London to Brighton main line; initially, the air services will be those to the Channel Islands and the near-Continent. The terminal building will be reached from the road by raised approaches leading to a high-level forecourt; from the trains there is a covered bridge leading directly from the platforms to the passenger hall. Stage 1 of the project, designed and built in less than three years at a cost of around £7 million, is now substantially completed and is to be opened by H.M. The Queen on Monday, 9 June.

Prior to the war there was a small airport at Gatwick which, in its time, was the most advanced of its kind in Europe. During the war, it was a fighter station active in the Battle of Britain. Its successor, with road, rail and air services meeting together at the one point, also makes communication history.

*The Runways*




*Site Plan*

### CHOICE OF SITE

With the rapid growth of civil aviation in the years following the last war, it became necessary in 1952 for the Government to undertake the expansion of airport facilities in the London area, in particular to provide an alternative to London Airport. The decision to develop the existing aerodrome at Gatwick was then made.

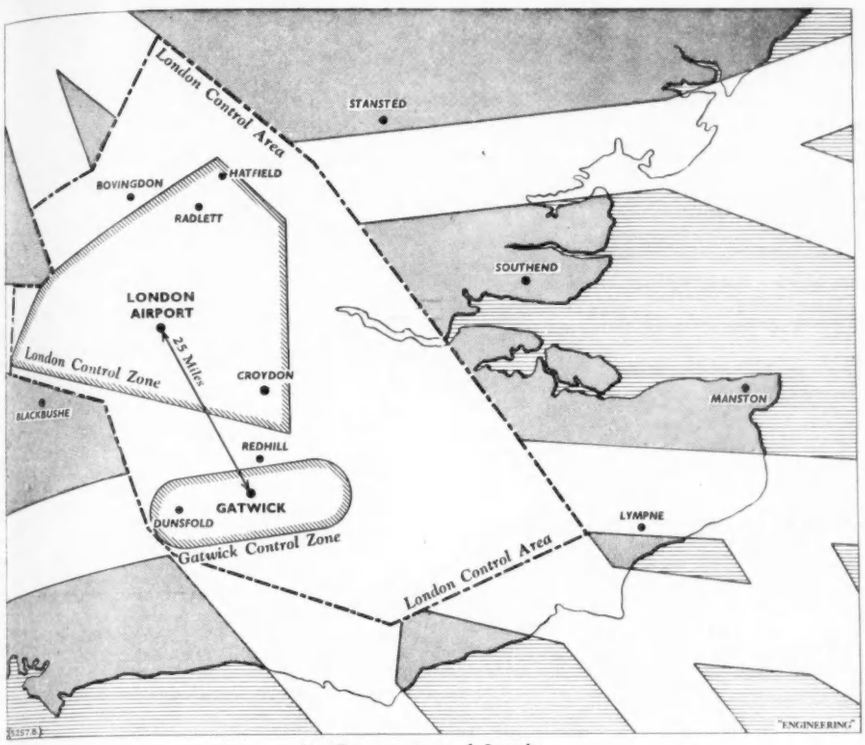
The old aerodrome there had existed prior to the war and was privately owned by Airports Limited. It possessed a number of features that made it most suitable for the Government's plan. Firstly, it had convenient and rapid access by road and rail to London. Secondly, it was on the main air routes already serving the capital, shown on the map opposite. Thirdly, it frequently has good visibility when that at London Airport is bad. Before deciding upon Gatwick, however, all airfields and possible sites were examined.

Of the five minor airports near to London, three—Blackbushe, Bovingdon, and Stansted—were unsuitable because of air traffic control problems, and the other two—Croydon and Gatwick—were too small. Bovingdon and Blackbushe both suffered from their nearness to military airfields, and, in the latter's case, to the experimental flying undertaken from Farnborough. Stansted was both outside the main flying routes, which are concentrated to the south and south-east of London, and without established road or rail access to the capital. Croydon, apart from being too small, could not be extended because of surrounding housing estates. Dunsfold, which was also considered, has poor access to London and is regularly used by military aircraft for which an alternative base would have had to be found. Gatwick, on the other hand, besides the features already mentioned in its favour, was in open country nearly free from unwanted surface gradients.

### LOCATION

Gatwick, for the reasons stated, was deemed to be the most suitable site for the Government's plans. Objections to the choice were of two kinds, "local" and "idealistic." Those criticisms made within the second group were primarily that neither the road nor rail facilities were adequate to serve a major airport, thereby ignoring the fact that those facilities were a lot worse at any of the other possible sites and that providing them, perhaps from scratch, would have involved both delay and expense. Local objections were based on the nearness of Crawley New Town and of other, though smaller, residential areas. The need to divert the Brighton road around the new airport was also a criticism made against the choice. Some loss of accommodation had to be accepted and, in fact, some 60 houses, a hotel and a small factory either on or near to the site have had to be demolished. Several hundred trees have also had to be felled. Some good farming land has been lost, but on the other hand about half that taken over will remain in use for agricultural purposes.

The reasons for the choice of Gatwick were finally set out in Command Paper 8902. There it was stated that initially all the traffic operating to the Channel Islands and near-Continental resorts, as well as unscheduled flights, would be transferred from London Airport to Gatwick. As the alternative to London Airport, it would have to be capable of receiving the much larger aircraft used on inter-Continental flights. Nevertheless this fact did not mean either the lengthening or the strengthening of the proposed runway since, it was argued, aircraft diverted from London Airport would be near the end of their flight and therefore be flying light, having used most of their fuel; when taking off these same aircraft would also be light for they would




*Air Routes around London*

only be flying as far as London Airport prior to their normal departure.

It was also proposed to develop Gatwick in two stages. The first stage is now practically complete; as yet no decision has been taken about the second stage, though the present layout provides for duplication of the runway and the extension of the buildings. The whole of the work has been designed and constructed since the consulting and co-ordinating engineers, Frederick S. Snow and Partners, London, were appointed in September, 1955. Erection of the terminal buildings, laying of the runway, apron and taxiways, alterations of the railway station and diversion of roadways, together with all the subsidiary works, have been completed since the main contractors, Sir Alfred McAlpine and Son, Cheshire, reached the site early in 1956. The work has involved some of the most intensive heavy civil engineering and building ever undertaken in this country in connection with an airport.

## LAYOUT AND DESIGN

The runway and taxiways are shown on the illustrations opposite. Ultimately there will be dual parallel runways connected by turn-off strips and parallel taxiways leading to a terminal area with the maintenance area to the south. The decision to make use of the Racecourse Station (not the existing airport station half a mile further south) fixed the location of the terminal building, since it was a prime intention that the distance between the rail facilities and the air service should be a minimum. The orientation of the runways was made roughly at right angles to the railway and to the west of the old airport, which is now occupied by the terminal area. Together these dispositions dictated the location of the apron and hence the connecting taxiways.

For the first stage only one runway has been completed. It is 7,000 ft long and 150 ft wide. This length is sufficient for the aircraft—primarily Viscounts—which will use it, and will safely accept larger aircraft diverted from London Airport after long flights. The layout will enable a high rate of aircraft movement to be obtained: the turn-outs leading to the taxiways will permit aircraft to leave the runway while travelling at 50 m.p.h., two such turn-outs having been provided for machines landing in a westerly direction (the most used) and one for those coming from the east.

On both sides of the runway there are hard shoulders, 75 ft wide, which are of flexible construction having a strength roughly half that of the runway. These shoulders will ensure that aircraft running off the runway will not encounter a sudden change in support, with a consequent risk of crashing or other damage. The top surface of the runway has been coloured dark grey, by the inclusion of 0·1 per cent of carbon black in the concrete mix, to reduce glare and to add to the conspicuity of the white runway markings. In contrast, the shoulders are tinted pink. The taxiway system allows for fast taxi-ing from the terminal area to the runway with run-up areas at each end of the runway.

Much thought has been given to the approach and runway lighting. There are both high (white) and low intensity (red) lights for the approaches and the runway, taxiway and edge lights, and a centre light system which is unique. The centre lines of the approaches extend 3,000 ft beyond both ends of the runway and the intensity of lighting can be varied according to conditions. The runway lights, of the elevated type, are spaced at 200 ft intervals for the full length of runway. A series of green threshold lights have also been installed and the same colour is used for the centre-line lights along the taxiways. These centre-line lights lead the pilot off the runway, along the turn-outs and on to the taxiways. Blue edge lights are fitted around the edges of the run-up areas and for a short distance along the taxiways. In addition, the pilots are to be aided by a system of graduated lights at each end of the runway, especially devised to overcome the feeling experienced by pilots on landing into blackness. Four companies have been responsible for supplying lighting equipment: G.E.C., Holophane, Revo Electric and Benjamin Electric; its installation was undertaken by T. Clarke and Company Limited, Sloane Street, London, S.W.1.

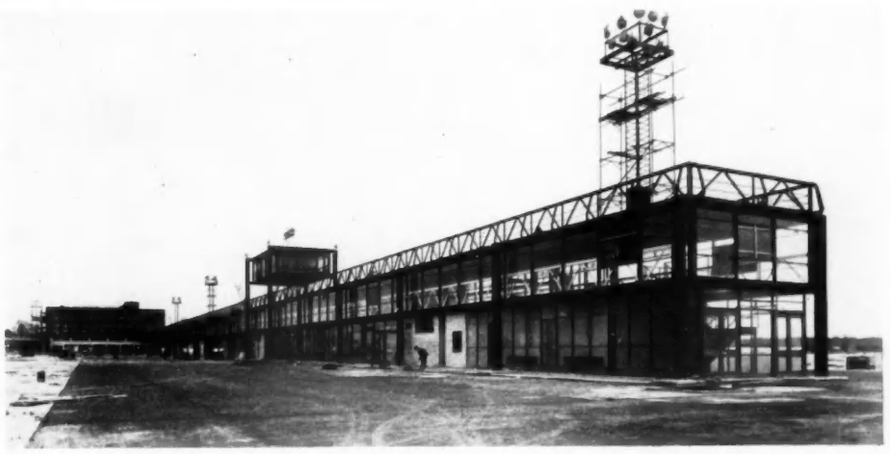
The electrical services in support of an airport of the size of Gatwick are, of course, extensive and extremely complicated. The main supply is taken from the South Eastern Electricity Board at the intake sub-station in the north-west corner of the old airport. From this sub-station, an 11 kVA ring main circles the entire airport, linking it with transforming and switchgear centres which distribute power at medium voltage to the airport installations, including lighting control centres and standby plant. Crompton Parkinson have been responsible for the ring main cabling, Greshams for the transformers, and Yorkshire Switchgear for all the switchgear.

The control tower is situated north of the mid-length of the completed runway. To allow for the extensive installation and running-up required, this building was handed over in November, 1957. It houses both main control and radar rooms and, to ease the difficulties of installing equipment, a comprehensive system of horizontal and vertical ducting has been built in. The building contractors for this work were Gilbert-Ash Limited, who also built the adjacent fire station and a small boiler house.

Gatwick is equipped with all the radar and navigational aids necessary to give full and precise control of aircraft. A Cossor unit on its own site just east of the control tower provides short and medium-range coverage of the airport and the approaches. Marconi equipment, on the other side of the tower, will be used to locate machines between 1 and 110 miles away; this equipment is of the same type as that which has been in service at London Airport since 1952. In addition the Pye instrument landing system has been installed, as well as GCA and ILS systems to cover poor weather conditions (see also "Automatic Landing Equipment" p. 664,). The usual VHF/RT equipment is to be used for ground-to-air communications.

## TERMINAL AREA

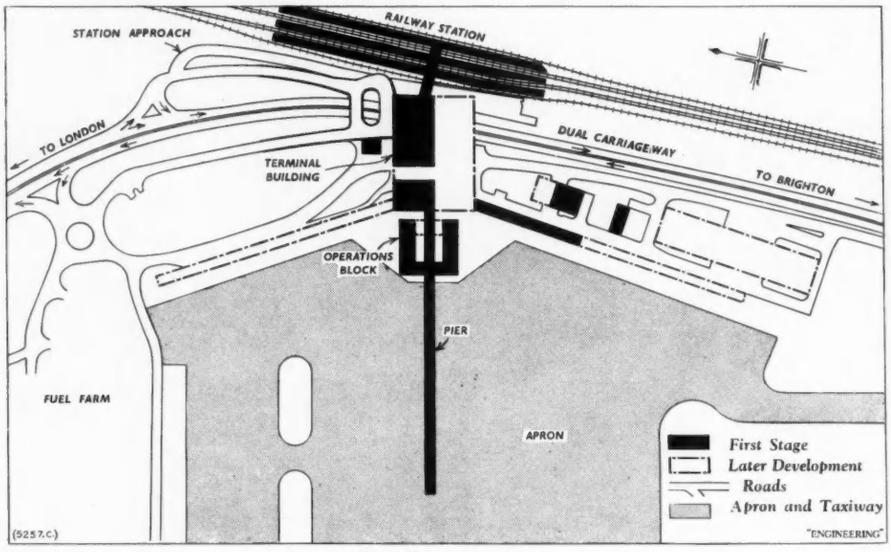
In the terminal area there is the apron with stands for 18 aircraft; the terminal building itself and its "pier" (described in some detail below);



*The Pier*

*Continuing*

## The New Gatwick Airport




*The Terminal Area*

in front of the terminal building is the operations block where flight information and meteorological briefings are given, and in which the signal centre and the airline operators' offices are located. To the south there is a staff canteen and central boiler house which serves the whole area, including the railway station. Further south there is accommodation for spectators.

The maintenance area is on the southern side of the airport and in the region formerly occupied by the old airport. In this area the principal installation is the pumphouse which serves the fire hydrants throughout the airport; the pumphouse also handles all sewage from the maintenance area (and some local sewage), passing it to the main outfall on the north side.

One operator, Transair Limited, has already constructed a large hangar and administrative installation in the maintenance area and BEA are about to begin building.

To the north of the apron there is a fuel farm with two separate installations—one for Esso, the other for Shellmex and B.P.; each installation can store about 144,000 gallons of aviation spirit and turbine fuels of different grades. Both groups will use tankers and trailers to take the fuel to the aircraft and in each case a full 24 hour service will be maintained seven days a week.

### PASSENGER MOVEMENT

The terminal building itself is 350 ft long by 135 ft wide; the main floor at concourse level is carried on heavy columns at spacings of between 60 and 70 ft. Below the level of the concourse, and in the space between the trunk road and the airport service road (which enables road traffic to get from one side to the other of the terminal building) are the services for baggage handling and technical installations. Above the concourse the construction is of reinforced concrete and comprises the restaurant floor and the roof. The whole building is clad in a simple system of steel mullions and glass in wooden frames which has ensured a flexibility of layout and speedy construction. Considerable use has been made of prestressed concrete for the heavier beam sections and of pre-cast members, though slabs have been cast *in situ*.

From the passenger's point of view Gatwick should show several advantages over earlier airports. For one thing there is no formal customs hall for outgoing passengers. Passengers subject to a customs check will have their luggage examined at the ticket counters, with last minute personal customs and passport checks at the western end of the concourse. They will thus be free to stay in the concourse or restaurant until they are called for their aircraft, when they will proceed directly to the planes without being segregated under customs bond in a waiting lounge. Passengers for flights not subject to customs will leave the concourse by a staircase leading down to the pier without passing through the customs barrier.

For passengers arriving from abroad customs and immigration halls are necessary. These will be reached through the pier and are located on the mezzanine floor below the concourse. Passengers coming off internal flights walk through the pier and up the staircase into the concourse. Baggage movements are also quite straightforward. On being surrendered at the ticket counters, luggage descends on a conveyor to the baggage handling area below the concourse and thence to the aircraft by truck. Similarly incoming luggage is brought into the building and then dispatched by conveyor either to the customs or to the concourse for collection.

The pier is, as may be seen from the illustration on the previous page, a covered walkway to the aircraft. It is a two storeyed structure 900 ft long, 19 ft wide by 20 ft high, and is of welded steel construction designed as a series of bridges spanning 40 ft between welded portals; the walls, for the most part, are of glass. The ground floor provides office accommodation for airport personnel, crews, customs clearance and passenger-assembly areas; the first floor is the main walkway for passengers, both coming and going. Surmounting the pier, the roof is in the form of a gallery where visitors may watch either the passengers, the aircraft or both. Spectators who walk the whole length of the pier, as they may, will pass the marshaller's tower, from where the movements of aircraft on the apron to and from the taxiways will be controlled.

At the other end of the terminal building is the footbridge leading to the railway platforms and the inclined road approaches and elevated roundabout. The ramps and roundabout together form a clover-leaf connection so that airport traffic can leave and enter the dual-carriage way in either direction without crossing the path of oncoming traffic. The layout is shown in the terminal site plan (left) and the photograph below shows the reinforced concrete construction of the roundabout just prior to completion.

Passengers travelling by rail to the airport will be under cover from the moment they arrive at Victoria. Southern Region fast trains on a special airport service will pull into either side of a 30 ft wide island platform; lifts will take passengers up to the level of the footbridge which leads into the concourse where most of the railway facilities—ticket, parcel and enquiry offices—will be situated. Fast trains on the railway services to the coast will continue to run through the station which now has three island platforms, all of which are connected to the footbridge by staircase and lifts. The same contractor, James Langley and Company, Limited, Crawley, has been responsible for the new work as originally built the station in 1891. This new work has included the lengthening by 100 ft of all three platforms to receive 12-car trains; the conversion of the western platform (that nearest to the airport) into an island platform, with an embankment for the new loopline; and the erection of improved awnings. New signalling has been installed and considerable alterations have been made by the British Transport Commission to the trackwork so that a comprehensive service can be provided for the airport.

The station is to be equipped with plug-in loudspeakers with over-riding control from the signal box. It is also proposed to introduce a system of recorded announcements for relay to the western (airport) platform and operated from push-button panels. These recordings will be bilingual to assist foreigners who will be travelling. Illuminated departure indicators will be fitted over the entrance to the footbridge in the concourse and other indicators on the platforms will show the principal calling points of the trains.

*Elevated Road Approaches*

The main contractor, Sir Alfred McAlpine and Son Limited, was appointed in 1956. This company have carried out all the main civil engineering work at the airport, comprising a major drainage programme, construction of the runway, taxiways and apron, and foundations for the terminal building.

The construction programme was evolved by the consultants and took account of the division by the Brighton road of the site into two parts, as may be seen from the site plan (page 652). This division remained effective until August, 1957, when the road diversion was completed by Tarmac Limited, who were contractors to the Surrey County Council for this work.

On the west side of the site work commenced at the far end of the runway, working in an easterly direction, major drainage being undertaken first. The River Mole, which cut across the line of the runway near the western extremity, was put into a reinforced concrete culvert 1,400 ft in length. This culvert is 15 ft wide by 7 ft 6 in high and was designed to take the weight of passing aircraft under all conditions. On the east side the runway was cut by Crawters Brook, and this has been diverted in an open reinforced flume, along the southern boundary of the airport, to join the Mole at the southern end of the culvert. These works were completed early in 1956 and enabled major earthworks to be begun as soon as the weather was suitable in 1957.

The drainage of the paved areas and of the airport generally has presented a problem, both in design and construction. The whole area is very low-lying and liable to flooding, the natural run-off falling gently towards the north. The final level of the runway, which is constant along its length, was fixed so that good drainage was obtained and the flow of water into the River Mole is now to be limited (to 28 cusecs) by the construction of large, shallow balancing ponds built with weir outlets. One of these ponds in the area of the old airport is to be used to store water for fire fighting purposes. In addition to the drainage problem a further factor which restricted the construction of the main runway was the extensive ducting required for the lighting installations.

During the summer of 1957 the major earthworks were carried out, principally on the eastern side of the site. For this work McAlpine's used large, rubber-tyred scrapers, each capable of moving up to 600 tons of material a day. In the apron area a mound known as Gorse Hill had to be removed. The mound comprised Weald clay with various kinds of shale below, all of which was used in constructing the runway. On the west side, due to the shortage of materials, filling was imported from Kent and Sussex to bring the sub-grade up to the required levels.

The runway top concrete, 12 in thick, is laid on a 4 in lean-mix base overlaying the clay and hogging sub-grade. Laying of the base began in April 1957, and continued through the remainder of the job, just ahead of the principal concrete trains. The top concrete was required to have a minimum crushing strength of 5,000 lb per sq. in at 28 days and had to be laid to a tolerance not exceeding $\frac{1}{8}$ in per 10 ft, there being crossfalls in both directions from the centreline to aid drainage. The runway is un-reinforced and was laid in 15 ft wide strips which were afterwards sawn into lengths of 15 ft, fibreboard being inserted to complete the contraction joints. Steel formwork was used to obtain the close tolerance of surface levels and the surface brushed to give a skid-resistant surface.

A new feature of runway construction has been the use of a polythene membrane laid between the lean base and the top pavement. This membrane, though only 0·003 in thick, prevented loss of moisture from the top concrete and reduced the restraint and friction between the two slabs. It proved very tough and has been extensively sprayed on to green concrete, including the runway, during the curing period. At the peak periods of placing concrete, the contractors had five paving trains at work simultaneously, and to feed them two large batch mixers were installed on the east side and one on the west side of the contract. Concreting was substantially completed before the winter of 1957-58.

Construction of the runway shoulders was commenced in the summer of 1957 and completed in the spring of this year. A sub-base of Chichester wall ballast was laid, followed by 4 in of lean concrete. Above this there is a tar-based surface and the shoulders have been topped with pink Newton Abbot chippings.

In January 1957, the Turriff Construction Corporation Limited, of London, were appointed the principal building contractors for the terminal building and other blocks in that area; subsequently they were appointed for other buildings, including the pier. The foundations for the terminal building had been laid by Sir Alfred McAlpine and Son, Limited, under a separate contract, and this company also made the prestressed beams for the concourse floor. The contractors for the steelwork for all the principal airport buildings were James Austin and Sons (Dewsbury) Limited, Yorkshire.

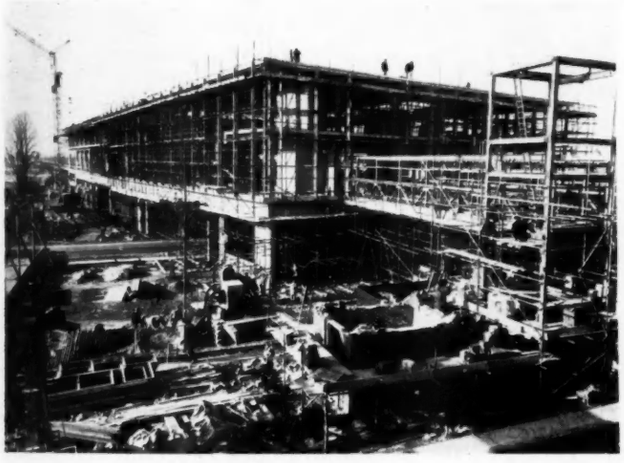
## ROAD APPROACHES

The major problem in the construction of the terminal building arose from the straddle position it occupied over the Brighton road diversion. (This problem will be even more complex if and when stage two of the project is undertaken, for the extensions will also cross the roadway.) A tower crane, working to the west of the road, was used to erect the reinforced concrete frame which supports a roof of steel construction carried on lattice girders of 80 ft span. The frame was completed by January, 1958. On all four sides there is glass walling, over 30 ft deep, carried on a steel frame of heavy channels with rolled steel mullions 20 ft apart. This part of the steelwork, some 165 tons, was shot-blasted and metal-sprayed with aluminium before receiving the finishing coats of paint at site.

As already described the design of the terminal building required the main concourse to be above the level of the adjacent road and rail, access being obtained by 24 ft wide approach ramps and an elevated roadway and by the footbridge from the railway. The ramps and roundabout—together with a cycle and pedestrian tunnel to the north—have been designed to allow free flow of traffic to and from the airport.

The ramps up to the roundabout are, at their lower lengths, earthen banks of Weald clay, with reinforced concrete bridge construction at the higher sections. Care has been taken to locate the supporting columns to give minimum obstruction to the sight lines from vehicles moving round the curve of the motor road below. Foundation problems were encountered during construction of the flyover—for which Turriffs were also the contractors—because of all the other work proceeding simultaneously in the immediate neighbourhood. The Gatwick stream passes through the same restricted area, and this has been put into a culvert.

Almost incredibly this new airport at Gatwick, with all the complexities arising both from the integration of road, rail and air communications and the provision of modern flying aids, has been designed since September, 1955. Constructing the runway and taxiways, preceded by extensive earthmoving and drainage works, together with the erection of several substantial buildings, —and even more involved installations—has been completed in just over two years. The first trial landings are expected as we go to press. In early June the Queen will open Gatwick Airport and the first holidaymakers bound for the Channel Islands will leave shortly afterwards.



*The Terminal Building*

*The Station and the Terminal Building*

# In Parliament

## FINDING MORE PLACES AT THE UNIVERSITIES

In the House of Commons last week, Mr. Malcolm MacPherson (Labour) drew the attention of the Chancellor of the Exchequer to the need for ensuring that qualified applicants for degree courses at the universities who had so far failed to secure admission to such courses should be able to obtain entry during the coming academic year. He also wanted an assurance that all new applicants who were properly qualified should also be able to obtain admission.

Emphasising these views, Mr. MacPherson said that in the announcement which Mr. Heathcoat Amory had made to the House on 20 February a figure had been stated which the Government hoped to achieve over a number of years. Was it not realised that, until that figure was reached, there might be a considerable wastage of potential university students, as indeed there appeared to be at the present time? Two sessions ago, the Financial Secretary to the Treasury had given a figure of roughly 2,500 as that of the number of persons who were qualified to attend courses at universities, but unable to obtain places there. Was it not desirable, therefore, that some attempt should be made each session to make sure that all qualified students should be fitted into university courses?

### 124,000 STUDENTS IN THE 1960s

The announcement he had made on 20 February, Mr. Heathcoat Amory said, showed that the Government were alive to the need for a further increase in the capacity of the universities, and he was confident that the university authorities would do their best to find places in the coming academic year for applicants whom they considered qualified. University capacity was steadily expanding. The programme already announced provided for a further expansion in the years ahead, but he thought there was perhaps some misunderstanding about the word " qualified."

It was commonly considered that the possession of two passes at the advanced level in the General Certificate of Education examinations was a minimum qualification. It should be borne in mind, however, that the actual standard demanded for admittance depended upon the judgment of the university or institution concerned.

[In the announcement referred to, Mr. Amory said that Government approval had been given for the starting of university buildings up to the value of £10·4 million in 1957, up to £12 million in 1958, and to £12 million in 1959. Authority had been given for a programme to be prepared on the basis that further building projects would be started up to a value of £15 million in each of the four years 1960 to 1963. It was difficult to put a precise figure on the increase in university students on the basis of such a building programme, but discussions between the University Grants Committee and the universities had been based on an increase to about 124,000 students by the mid-1960s, with the possibility of a further temporary increase of 10 per cent during the second half of the decade. Universities were expanding faster than expected and the increase beyond the 124,000 foreseen for the late 1960s might well prove to be permanent.]

### VARYING THE STANDARDS

Mr. Arthur Woodburn (Labour) considered that it was all a matter of varying standards for admission. He pointed out that Professor Sir Edward Appleton had shown in a recent report that entrants to the universities could be included or kept out by raising or lowering the admission standards. Was there any sense in excluding people from the universities who were obviously qualified to benefit by a university education? He suggested that if students could not secure admission into one course, there should be the possibility of accommodating them in another. If necessary, was there any possibility of persuading such students to take another course and thereby give their best brains to the nation in whatever sphere work could be found for them?

The Chancellor's attitude seemed to be that a university education was some privilege conferred on the students. In fact, it was the need of the nation that the best brains of its people should be developed to the utmost extent possible.

On these other matters, Mr. Amory said that students could apply to as many universities or institutions as they wished, but it could not be denied that there were more students at the present time than there was capacity for them in the universities. What also was true was that the number of university places was steadily being expanded. The programme announced in the House on 20 February provided for considerable further expansion.

Mr. Amory said that he entirely agreed with Mr. Woodburn that the best brains in the country should be fully developed and it was for that reason that the Government had embarked on its very extensive expansion programme.

## INTERNATIONAL LABOUR MISSIONS

A question was put to the Minister of Labour and National Service by Mr. R. E. Prentice (Labour) asking for details of the resolution of the Governing Body of the International Labour Office establishing a survey on the freedom of association among workpeople, to which the Government had taken exception. This attitude, Mr. Prentice said, had led to the United Kingdom delegate abstaining from voting on the proposals.

The suggestions before the Governing Body, Mr. Iain Macleod said, authorised the director-general of the ILO to arrange directly with governments for the sending of missions to carry out studies in their countries for the purposes of the survey, without further reference to the Governing Body. In the Government's view, the authorising of such missions, for which the estimated cost was disproportionately high, should remain within the control of the Governing Body and should be used only if other methods of assembling the required information proved to be inadequate.

It had also been proposed that the survey should be of wide scope, covering all relevant aspects of national life, including those features of the political, economic and social conditions which affect the conception and practice of freedom of association in the countries concerned. In spite of requests for clarification, more precise explanations of what was intended were not given. In the Government's view, the scope of the survey needed to be more closely defined and should not be extended to matters outside the proper field of the International Labour Organisation.

## SOUTH AFRICAN URANIUM

Mrs. Barbara Castle (Labour) wanted the Under-Secretary of State for Commonwealth Relations to give details of what had been decided at the recent official discussions in Pretoria with representatives of South Africa on uranium production in the Union.

Mr. C. J. M. Alport replied that he had been told by the United Kingdom Atomic Energy Authority that agreement had been reached concerning the quantities of uranium to be purchased in the coming years by the Combined Development Agency. That body was the organisation through which purchases were effected on behalf of the UKAEA and the United States Atomic Energy Commission. The quantities to be purchased would maintain production at about the present level. In other respects, the contract remained unaltered, except that, in future, any uranium produced in excess of the agreed figure would be available for sale elsewhere.

The representatives of the United Kingdom Authority also had discussions with the South African Atomic Energy Board regarding the Authority's undertaking to purchase uranium unilaterally from South Africa. Agreement had been reached on the quantity to be bought and the price to be paid.

## RAF TRANSPORT AIRCRAFT

A matter brought forward by Mr. Geoffrey de Freitas (Labour) concerned contracts for spare parts for Royal Air Force transport aircraft. He wanted to know in what year each of these types of aircraft had entered squadron service and said he felt that it became increasingly expensive to maintain these old aircraft. He suggested that the Minister of Supply should use his influence with the Air Ministry to ensure that old, out-of-date aircraft were scrapped and replaced by modern machines, which were considerably cheaper to maintain.

Mr. Aubrey Jones said that there were current contracts for spare parts for all transport aircraft in service with the RAF. These machines comprised the Beverley and the Comet, which entered squadron service in 1956; the Hastings and the Valetta in 1948; the Viking in 1946; and the Dakota which came into service during the war. In addition, there were spare parts on order for the Britannia, which was not yet in service with the RAF. As he had pointed out on various occasions, his ministry had as yet received no requirement for a new transport aircraft.

### BOAC South American Route

Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, said that it was the intention of the British Overseas Airways Corporation to re-open their direct service to South America in the spring of 1960. That time was the earliest at which the Comet IV aircraft would be available for service on this route, and the Corporation's decision was subject to a satisfactory financial assessment of the route when the time came. He told Mr. Frank Beswick (Labour/Co-operative) that he understood the Corporation had in mind the institution of a service operated throughout by themselves.

### London-to-Yorkshire Motor Road

Mr. G. R. H. Nugent, one of the two Joint Parliamentary Secretaries to the Ministry of Transport, reported that the proposed line for the London-to-Yorkshire motor road through Leicestershire was still not decided, and that his ministry was awaiting the further views of the County Council. Asked by Mr. Albert Roberts (Labour) when he expected to publish his proposals for bringing the road into the West Riding of Yorkshire, Mr. Nugent said that the route must be decided first. He could not say at present when the draft proposals would be published.

### Safety of Electrical Appliances

The Parliamentary Secretary to the Board of Trade, Mr. F. J. Erroll, told the House that the joint committee of the Electrical Development Association and the British Standards Institution on the safety of electrical appliances and accessories was set up after the recent war to test and advise on cases submitted to it where there may be doubt with regard to the safety of such apparatus. He understood that the committee would continue to operate as at present and that no development of its work was contemplated.

Miss Elaine Burton (Labour) asked if the Minister was aware that the Consumer Advisory Council of the BSI had been pressing for a long time for a Kite Mark scheme for these appliances, and whether he could give any indication of whether the scheme was likely to materialise. Mr. Erroll said that he would make inquiries.

**Special Article**

# TRAINING AFRICANS FOR OPERATION AND MAINTENANCE

*By Austen Albu*, B.SC.(ENG.), A.M.I.MECH.E., M.I.PROD.E., M.P.

*Mr. Albu has recently returned from a visit to Kenya, Somaliland and Aden, arranged by the Commonwealth Parliamentary Association. In this article he reports on the way Africans are being trained to operate and maintain engineering plant and products.*

With the growth of nationalist feeling among Africans, there has been a great increase in their thirst for education. This generally takes the form of a demand for a qualification for a white collar job, to provide as closely as possible the work and conditions enjoyed by the ruling race. To some extent this attitude has been fostered by the local colonial administrations themselves, whose first demand of the educational system has been that it should provide clerks for the government service and whose second requirement is, naturally, for teachers. Industrial and commercial firms who, in the early days of colonial rule, were mainly exporters of commodities or importers of manufactured goods, add to the demand for clerical staff and salesmen. Recently the oil companies have been among the largest recruiters of Africans with any sort of higher education.

To-day, however, the economic development of the colonies is hindered by the lack of skilled and technically trained staff. Their political and social development is unbalanced because of the inability of Africans to fill all the levels of the economic pyramid. With the growth of African incomes from agriculture, and the consequent development of an African market for consumer goods, it is now becoming urgently necessary to correct this unbalance and a number of interesting projects have been commenced.

Africans start with the disadvantage not only of a very low educational level, but also of no industrial or craft tradition and no mechanical toys in childhood to accustom them to the obstinate impersonality of materials and machines. There are very few apprenticeship schemes and their place is taken by trade schools, of which the number is being slowly increased. New legislation on apprenticeship, to include some system of awards for successful completion, is under consideration.

The East African Railways and Harbour Administration, and the Posts and Telegraphs Administration have for long run their own apprenticeship and training schemes, with residential schools, for all classes of staff which they require. The new railway school, built at a cost of £500,000 and opened in 1956, would be an outstanding institution in any country. Set up on a 55 acre site on the outskirts of Nairobi, it provides training in traffic operation and mechanical engineering for Europeans, Africans and Asians alike. The number of students in residence this year is nearly 600 and the number of applications received for these places was over 8,000. Apart from the cadet grade, entry to which requires a degree or professional qualification, there are two grades of engineering apprentices, the first, intended for the higher technical positions, being recruited from those with good Cambridge Overseas School Certificates with credits in English and Mathematics. They do a five-year course of which, although some are resident at the school, the theoretical part is at present taken at the Royal Technical College, Nairobi, and the practical in the railway workshops. Last year there were 29 Europeans, three Asians and six Africans in this group, but the number of Africans is growing. The Grade II engineering apprenticeship is intended for tradesmen, recruited at the age of 15½ to 17½ from those who have received eight to nine years education with the appropriate intermediate school leaving certificate. The course is of five years duration, of which the first is spent at the school both in training workshops and classrooms; during the remaining four years, one day a week is spent in the school and the remainder in the main workshops. Last year there were in this grade 204 Africans, three Asians and no Europeans.

In addition to the regular courses for engineers, tradesmen and traffic staff there are shorter courses for drivers and clerks, special courses for senior supervisors, and refresher courses for guards, station-masters and railway police. Although all instruction and recreational activity is multi-racial, there is at present separate hostel accommodation for each race. This partly arises out of differing dietary requirements, but the principal of the school expects this division to be spontaneously broken down in the near future. Grade I apprentices and trainees have

**Station-masters of the future undergoing practical instruction at the East African Railways and Harbours training school, Nairobi.**

**Trainee plumber threading a water pipe at a trade school in Kenya.**

better accommodation than Grade II, but the standard of each race is equal and very high indeed. The apprentices share an active social life, with games, current affairs discussions and a St. John ambulance section 60 strong; in addition, they maintain the gardens round their hostels.

A new venture, now just over a year old, is the technical training school started in Nairobi by Gailey and Roberts Limited, a subsidiary of United Africa Company. This is intended to train maintenance mechanics for the various makes of tractors, pumps, earth-moving machinery and other farm equipment for which the company are agents. The training workshop is situated at one end of a new maintenance workshop, with classrooms above. The course consists of two years general workshop practice and theory followed by three years on-the-job training on specialised equipment. Each apprentice is moved round to work on a variety of equipment and then chosen for the type of work for which he is most suitable. Apprentices are encouraged to attend part-time evening and day sandwich courses. Last year's intake consisted of 12 Africans, one Seychellois, four Europeans and two Asians. The entry level is school certificate or a period in a trade school. Africans live in a hostel for the first two years; Europeans and Asians receive a housing allowance in addition to their pay. Two recent advertisements in the *East African Standard* brought in 1,100 applications from all over East Africa for 20 places.

In order to cope with the selection problem which this presented, 100 applicants were called for interview and 40 of them were chosen for testing by the Aptitude Testing Unit set up by the Prisons Department in 1953 for the selection of warders and for selecting prisoners for training. This admirable little unit is now doing more work for industry and other public departments than for the prison service. Its value can be gauged from the fact that the second-year intake to Gailey and Roberts' training school is stated to be streets ahead in quality of the first year.

Another apprenticeship scheme, although on less developed lines, is that of the African Marine and Engineering Company at Mombasa. Here there are about 20 indentured apprentices of mixed races. To deal with the perennial problem in Africa of non-completion of training, parents are required to make a deposit of 200 shillings, returnable on completion. There are two grades of apprentice: the first for English speakers and the second for those unable to speak English. So far none of the African apprentices has been able to speak English, the reason given being the preference of those with some education for white collar jobs—an explanation which conflicts with the present-day experience of other organisations.

One of the problems facing those responsible for apprentice training, especially at the technician level, is the absence of suitable technical institutes for part-time theoretical instruction. In Nairobi there is the Royal Technical College, an elaborate building whose proper function has just been the subject of a report in the recently published White Paper on Higher Education in East Africa. If the recommendations made by

## Marketing

# FINDING AND KEEPING CUSTOMERS

A mild, grey-haired man who was after a large machinery order said, early in his interview with the prospective buyer: " I'm not much of a salesman. You see, I have been on the buying end nearly all my life and I find myself constantly taking the buyer's point of view." It was not until he walked out with the order in his pocket that those who had heard him began to realise just how much of a salesman he really was. This little anecdote, taken from John G. Jones' book *Salesmanship and Sales Management* (Alexander Hamilton Institute, Modern Business series), is retold in a stimulating monthly letter from the Royal Bank of Canada. Selling is described as " the finding, winning and keeping of customers " and the letter explains and illustrates how understanding—of other people's needs, problems and attitudes—is the most effective weapon a salesman can have. Good generalship, based on first-class market knowledge, is needed to locate and define prospects. But, they go on to say, " a sale is not a coldly scientific process. It is a friendly, red-blooded, person-to-person transaction. The sales person needs to understand and apply basic principles of human behaviour."

The Bank's letter is based on the most up-to-date literature on salesmanship and market study. For example, it quotes the advice given recently by an advertising agency: " To women, don't sell shoes—sell lovely feet." Increasingly we no longer buy products but those enjoyments that go with them—not cars, but prestige; not professional services but freedom from trouble. Many sales engineers are well aware that they sell productivity, or automation, or control much more so than machines, handling plant or instrument panels. Above all, a sales engineer sells his understanding of the plant engineer's or the designer's problems. It is his job to help these people to solve them.

A sharp attack on British industry's ability to sell was made by the Chief Electrical Engineer of Odham's Press, Manchester, Mr. George H. Parker, in his chairman's address to the annual conference of the Association of Supervising Electrical Engineers at Hastings. He argued that many of the troubles of the electrical engineering industry were caused by its having far too long accepted the position that " it is a real concession for the manufacturers to supply the customer with what he wants." Too little attention was being paid to the customer's needs, insufficient effort made to inform him about the products the industry was selling and not enough care taken to interpret correctly customers' orders. Mr. Parker spoke strongly in favour of re-organisation of sales and service departments and for a redefining of their functions. " Complacency," he said, " is our current enemy." He spoke in favour of the Free Trade Area—" such vast potential markets should serve only to stimulate and encourage us "—but warned that the electrical engineering industry has much to learn in the fields of design, market research, marketing methods and after-sales service. In other respects—costs of labour and raw materials, technological knowledge and technical research facilities—Mr. Parker thought we could compete on more than equal terms.

Both the Royal Bank of Canada and Mr. Parker gave sound advice. But the most encouraging feature of the past year is precisely the way in which the engineering industry is doing just that. Engineers are sent on sales courses, markets are being surveyed, service teams are strengthened and encouraged to be helpful, foreign languages creep in in technical sales leaflets—in fact conversion to a new vital outlook is fast proceeding, almost as rapidly as the fall in delivery delays.

### Foire de Paris

The French love an excuse to visit their capital and most Frenchmen enjoy a good spectacle. Hence, perhaps the popularity of the Paris Fair. Last year, four million people visited *La Foire*, including 150,000 foreign buyers—principally Italians, Spaniards, Norwegians, Germans, Americans and Portuguese. No mention of Englishmen for whom doubtless Paris has ample attractions without its Fair.

British industry must beware it is not left out of too many exhibitions. Americans and Continentals—particularly Germans—consider international fairs one of the cheaper means of export promotion and one of the most appropriate sectors for Government assistance. Working models—now used so widely for atomic power station plant and other heavy equipment, could be a solution: a kind of circus, permanently on the move, perhaps in duplicate, or triplicate, to cope with simultaneous events.

### Model Examples

Working models are also prominent at the American Foundry Society's exhibition at Cleveland. There, half the total exhibits will operate, giving the visitors an opportunity to make on-the-spot comparisons of equipment being considered for their palnts.

The idea of working models has also been gaining ground in this country. Many were to be seen at the recent Mechanical Handling Exhibition at Earls Court, London. But there were also mobile cranes scraping the roof and huge dumpers and tractors crowding the hall. For heavy plant working models which can really work are probably the best answer to the trade public's need—not merely a device to attract attention.

### Fighting for U.S. Markets

A hard-hitting reply has been published by the British Chamber of Commerce to the case against the continued importation by the United States of foreign-built electrical generation and transmission equipment presented to Congress by the National Electrical Manufacturers' Association last February. " Not the slightest basis " exists for the arguments presented by NEMA, they say, to the effect that the installation and use of foreign, and including British-produced, electrical equipment in the United States will adversely affect national security. The contrary is closer to the truth.

A study of the comparative plant outage figures quoted by NEMA and presented as evidence of " different standards of performance between domestic and foreign equipment " disclosed that the figures quoted are neither directly related in terms of the period selected, nor in terms of a common base for outage comparisons. If this is remedied the NEMA figures are shown to be unsound. The arguments against import on the basis that the plant cannot be as readily and speedily serviced as would be the case for domestic products are demolished by the simple statement that " substantial manufacturing and servicing facilities exist in Canada." The so-called threat to domestic industry was found to amount to " only 1/10 to 1/30 of United States exports and still a smaller fraction of United States output."

### Progress in Canada

Speaking as the head of the British trade delegation now touring Canada, Sir William Rootes said that the first week had been " full of inspiration " and prophesied that by the time the delegation returns at the end of this month " trade between Canada and the United Kingdom should be given a good uplift." Indeed, the monthly trade returns show that the April figure of exports was one-third higher than the monthly average for the first quarter of the year.

Already there are signs that British manufacturers are following up the opening Mr. Diefenbaker, Canada's Prime Minister, made nearly a year ago. Charles Churchill have one of their directors, Mr. R. Gabriel, on a tour " to discuss the increase of the exports " of their machine tools to Canada. The Coseley Engineering Company of Wolverhampton are planning to distribute there the " Kingstrand " aluminium construction sheets fabricated in accordance with a system of building first developed in that country. Birlec Limited have made a survey of the Canadian market for their range of furnaces and have now formed a branch organisation in Canada to supply " the growing engineering and metallurgical industries in that country." A metallurgist with long experience of the steel industry is setting up a base for them in Toronto, the main centre of Canadian heavy industry. The visit of a mission sent by the Scientific Instrument Manufacturers Association of Great Britain (SIMA) is being followed up by member firms, some of them acting in groups, " to step up in Canada the provision of active sales promotion, improved stocks of spare parts and efficient after-sales service."

These are only a few examples of mounting activity in Canada on the part of British engineering firms. Sir William Rootes has good cause to be cheerful about the prospects of British exports to Canada. There is certainly no lack of support for his courageous lead.

## *Continuing* Training Africans

Professor E. Giffen of Queen Mary College, London, and Mr. D. H. Alexander, principal of the Royal College of Technology, Belfast, are accepted, the College will devote itself to professional and technological courses, with the aim ultimately of becoming the technological faculty of an eventual University of East Africa. At the present time, however, it is doing some lower level work and, in view of the greater need for this, it is difficult to see why it should not continue to do so for some years.

The Government propose to build a technical institute in Nairobi to house the work of the Kenya Technical Institute at present being carried out in the evenings in the buildings of an Asian Secondary Technical School. So far, however, its work has been almost confined to preliminary technical and commercial courses, although it is intended to enter students for the examinations of the Union of Lancashire and Cheshire Institutes or the London Chamber of Commerce. Unfortunately it appears that the reduction of funds available in the Colony may cause a postponement of the start of the new building.

In addition there are technical institutes at Kampala in Uganda, and technical education is given at the Mombasa Institute of Muslim education; but much of the latter is of a trade nature and no evening classes are at present provided. A technical institute is also in course of construction at Dar-es-Salaam which will provide full-time and part-time courses up to intermediate professional diploma standard.

It will be seen that there are now a number of developments taking place which should provide the technical instruction which East Africa will need as its industries develop. It cannot proceed faster than the pace of the secondary education on which it must be based. It is therefore important that the provision at the various levels —craft, technical and professional—should be maintained in a proper balance corresponding to the foreseeable needs of local industries.

**Book Review**

# WOOL OVER OUR EYES

**Motivation Research: Its Practice and Uses for Advertising, Marketing and Other Business Purposes.** By HARRY HENRY. *Crosby, Lockwood and Son Limited, 26 Old Brompton Road, London, S.W.7.* (30*s*.)

Motivation research is a hybrid between the customary techniques of market research and social psychology, jointly applied to the purpose of selling consumer goods. Its major question is the Why of buying behaviour; its axiom that in buying as in any other human action rational and irrational forces are at work; its *raison d'être* that knowledge of irrational motives in buying is an invaluable help to production and sales policy, packaging, marketing and advertising in efforts to transform potential into actual consumers. Motivation research was developed in the United States but has now spread to this country and the Continent.

Mr. Henry's book about motivation research is intelligent and lucid, and almost dispassionate even though it is written by one of the staunchest advocates of this still controversial technique. It is easy and agreeable reading, free from jargon and exaggerated claims, and full of examples demonstrating how motivation research manages to uncover hidden motives by ingenious and rigorously applied psychological research methods. The description of these research methods is admirable in its clarity even though a social psychologist might take exception to one or other of Mr. Henry's statements. The examples deal with matters such as the fact that one and the same product apparently tastes sweeter in one wrapping than another; that English housewives often feel guilty when they use cake-mixes—apparently being able to make a good cake from scratch is a more important hallmark of a good housewife than making coffee or soup; or that many drivers mistake a loose accelerator for a good pick-up performance of their cars. Motivation research blends into more traditional market research by concerning itself with the proportion and social background of strata of the population which exhibit these 'psychological characteristics to varying degrees.

The Americans have not only developed this technique; self-conscious and self-critical as they are, they have also led the debate about its inherent dangers. Books such as *The Hidden Persuaders* or *Organisation Man* speak of the disastrous consequences when the privacy of unconscious motivation is exposed for exploitation by the merchants of goods and ideas, or for the production of utter conformism in the junior executive. The recent newspaper correspondence in this country about subliminal advertising has contributed to that debate. Mr. Henry touches upon these issues and he is persuasive in debunking such fears, as far as he goes. But perhaps he does not go far enough. He is right in pointing out that no harm is done if a manufacturer learns to satisfy not only rational needs but also irrational desires by putting a red instead of a brown wrapper around his product. But what about the possibility that the red wrapper contains an inferior product?

What it comes down to is the question as to the place and limit of advertising in our economy. That it has a place, no one would deny; that it can all too easily overstep its limits is equally clear. If it does so, it is not the fault of the application of scientific techniques but of shortcomings in the morality of the commercial world and in the education of the public. The development and application of the human sciences cannot and must not be stopped by law. Psychology will push back the frontiers of ignorance as every other science does. Its misuse will be avoided not by indignation or preaching but by an educational counter-offensive. While *Motivation Research* can be recommended equally to the commercial world and the interested consumer, both will benefit from their reading most if after every chapter they read a page or two in *Which?*, the publication of the recently formed Association for Consumer Research, which has successfully launched this counter-offensive.

# TRADE PUBLICATIONS

*Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.*

**Mining Equipment.** WESTINGHOUSE BRAKE AND SIGNAL CO. LTD., 82 York Way, King's Cross, London, N.1. Five revised pamphlets for insertion in the Westinghouse loose-leaf mining equipment catalogue. They deal respectively with: pneumatic rams for moving cars or for other power applications, automatic gates for pit shafts, auxiliary valves for control of air supply, tub retarders, and skotch blocks for controlling tub movements.

**Spare Parts Charts.** A.C.V. SALES LTD., A.E.C. Works, Southall, Middlesex. Wall charts, 30 in by 20 in, giving exploded views of vehicle components. Available in sets of five, comprising engine, gearbox, rear axle (2) and front axle, for the following vehicles: Reliance with synchromesh, Mercury Marks I and II and Monarch Marks V and VI. Others will follow. Price 12*s*. 6*d*. per set, post free. Charts can also be supplied without printed key.

**Recessing and Backfacing.** BURTON GRIFFITHS & CO. LTD., Small Tools Division, P.O. Box No. 232, Montgomery Street, Birmingham, 11. Westwood automatic recessing head, with integral micrometer adjustment for depth of cut. Details of two types —with Morse taper shank, or with parallel shank for tool-holders of automatic machines. Illustrated booklet.

**Overhead Cranes.** LIFTING EQUIPMENT LTD., Chittening Estate, Avonmouth, Bristol. Overhead travelling cranes to order. Single and double-girder over or under-slung types. Normal and high speed electric hoists, and jibs. Capacities: single girder 10 tons, 40 ft span; double girder, 25 tons, 40 ft span, and lattice girders up to 100 ft span. Brochure.

**Bandsawing and Filing.** MIDLAND SAW AND TOOL CO. LTD., Pope Street, Birmingham, 1. Four bandsawing and filing machines: minor, table 18 in square sawing capacity 8 in; standard, 22 in table, sawing 9½ in; deep throat, 30 in table, sawing 14 in; and "Tridraulic," in various sizes, with hydraulic table motion and tension control. Four illustrated leaflets, one for each machine.

**Dynamic Balancing.** C. F. R. GIESLER LTD., Small Hall, River Place, Islington, London, N.1. Dynamic balancing machine for components from 1 oz to 30 lb, and registering plane and amplitude of unbalance simultaneously in a single run. Temporary duplicated leaflet, with a photograph of the machine.

**Instrument Transformers.** SMITH HOBSON LTD., Hersham Station, Walton-on-Thames, Surrey. Current and voltage transformers of various types, wound or unwound primary; ratios up to about 2,000 to 5 A and down to 2·5 VA burden. Voltage transformers up to 3·3 kV primary. Also small power transformers. Booklet.

**Needle Bearings.** NEEDLE BEARINGS LTD., 34 Fitzroy Square, London, W.1. Needle bearings, types and development; load capacities; working life; limits and fits; scaling and lubrication. Technical manual.

**Settling Tank.** LINK BELT CO., Prudential Plaza, Chicago 1, Ill., U.S.A. Uniflow settling tank for removal of solids; almost constant liquid velocity throughout. Design particulars in folder 2648.

**Grain Silos.** SCOTENCE WORKS, Ayr, Scotland. Grain silos from 15 to 50 tons, indoor or outdoor. Leaflet.

# On the Shelf

*By Frank H. Smith*

Catalogue 678 from Blackwell's, Broad Street, Oxford, deals with books on nuclear engineering. This is conveniently divided into main and subheadings and runs to 31 pages. But do not make the error one of my clients made and assume that because a book appears in this catalogue that it is published by Blackwell, who are booksellers.

Van Nostrand, 358 Kensington High Street, London, W.14, modestly point out that they could offer only one "technical" book for April and that is the third edition of D. E. Gray and J. W. Coutts's *Man and His Physical World*, at 51*s*. It takes 682 pages to give one a "lucid and thorough (*sic*) grounding in the fundamentals of astronomy, geology, mathematics, physics, chemistry and nuclear science." All this, as I say, costs 51*s*., yet a book on azaleas by the same publishers costs 67*s*. 6*d*. There's a moral somewhere here about the comparative values of flowers and science, but perhaps the plates have something to do with it.

I wasted a whole morning recently trying to get a ruling on something that has never yet, so far as I know, been ruled upon. What it amounted to was, where should a man put his F.R.S., before or after degrees? Of course, when it came to the point, I found myself wrestling with all the other qualifications and honours and I came to the conclusion that it would be a good thing for a brave or foolhardy BSI Committee to sit on. Books of reference did not help a lot; *Who's Who*, for instance, puts F.R.S. in front of degrees, but I had a feeling that they did that because they give the date of the award as they do for honours. In the end, I fell back on the obvious and asked the Royal Society, and they themselves put it *after* degrees (as do Civil Service Lists) which is a confirmation of what I suspected. Precedence for honours and awards is laid down and these are obviously first. But one does come up against this business of membership of institutions; and whether a member of one takes precedence over an associate member of another. Always last, of course, is M.P. since this honour may well be only shortlived.

The American Society of Mechanical Engineers' journal, *Mechanical Engineering* for April, includes an order form for their latest batch of preprints. A mere 80 of them.

Anyone interested in standard gear transmissions should not miss "Komparativna studija njemackog, americkog i engleskog standardnog proracuna za zupcane prenose" in *Strojniski Vestnik* (Slovenia). This as everyone knows is an article on the comparative study of German, American and British standard calculations of gear transmission. I can lend the journal to anyone interested. Another good article is "Proracun vijcanih spojeva," or bolted connections. The same journal has an article on the Slovene version of the Universal Decimal Classification.

Interesting and rare books are the contents of a catalogue from Frank Hammond (this is not familiarity but the firm's name) of 129 Steelhouse Lane, Birmingham, 4. They are mostly collectors' pieces. Mr. Hammond would do well to provide an index to his subject headings at the front of his catalogue.

*Technical Contents* is an American monthly giving the titles of articles in periodicals. It does *not* enable one to tell at a glance what has been published on any given subject in any given month. It does enable one to see what any particular journal (from a selection of about 125) has in its contents list month by month. I hope that is clear.

The Allegheny Ludlum Steel Corporation of Pittsburg has published a 384 page book (1957, no price given) entitled *Stainless Steel Fabrication*. This sounds like a Churchillian version of white lies.

**Research and Development**

# LUBRICANTS AT HIGHER TEMPERATURES

## *Assessing The Effects on Ball Bearing Failures*

*By D. Scott**

*The rolling four-ball test rig for assessing the effect of lubricant on the incidence of pitting failure in ball bearings has been modified to be used at elevated temperatures. Various synthetic lubricants, solid lubricants and silicone-type lubricants have been tested at temperatures around 200° C, and some tests have been carried out with high-speed tool-steel balls and solid lubricants at higher temperatures. Microscopic investigations of typical failures and the initiation of damage are described and discussed together with the results obtained.*

The development of gas turbine engines which require rolling-contact bearings that operate at temperatures far above previous practice has imposed new and severe requirements on the lubricants necessary for their successful operation. Turbine operating temperatures are, in fact, at present restricted by the properties of the lubricants and metals available. The successful assessment of lubricants at low temperatures by the four-ball rolling test [1,4] suggested to the author that, with a few modifications, the test could be applied to the assessment of lubricants at elevated temperatures. The results of an investigation on these lines is given below.

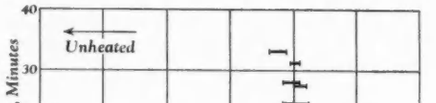



**Fig. 2 Time-temperature curve for synthetic lubricant to specification D.Eng.R.D.2487.**

### TESTS AT 200° C

The test rig consisted of a modified Boerlage four-ball lubricant-testing machine. A hard steel ball held in a chuck at the end of a spindle was rotated at a constant speed of 1,570 r.p.m. under load against three other similar steel balls allowed to rotate in a specially-designed lower race to give a combination of rolling and sliding similar to that experienced in angular-contact ball bearings. The upper ball thus took the place of the inner race in a conventional bearing, and was easily and cheaply replaced. The stresses at the contact point between the rolling surfaces and the upper ball were very high, and by suitable design of the lower race the stresses at the contact point were reduced, enabling one lower race to be used for a considerable number of tests. Loading was by a single lever system over a range of 70 to 750 kg. The arrangement of the test bearing and lower race holder, which incorporated a simple induction heating arrangement, is shown in Fig. 1.

A heater, wound with asbestos-covered copper wire consuming 3 amperes at 250 V heated the test balls, lower race and lubricant to 200° C in about 15 minutes. The temperature was measured with the aid of a manually-controlled thermocouple in the lower race or lubricant. A current of 1½ to 2 amperes maintained the temperature to within a few degrees centigrade.

Four commercial ½ in diameter steel balls were used in each test and were thoroughly washed in benzene and allowed to dry before use. Bath lubrication was employed, and for liquid lubricants a standard amount of lubricant (16 cc) was sufficient to keep the balls totally immersed. The machine was assembled ready for test, and the temperature was raised and then maintained at the required temperature for 5 minutes before the test commenced. Failure was detected by a change in the noise characteristics of the machine—a method found to be sufficiently effective to permit immediate detection of the presence of a very small surface pit.

Various synthetic lubricants, solid lubricants, greases and silicone lubricants have been tested at temperatures around 200° C. This temperature was chosen for preliminary tests because the only balls available were the normal commercial E.N.31 steel balls which are tempered below 200° C. Use of these balls at temperatures above 200° C would result in tempering of the steel, with a reduction in hardness. A few tungsten-chromium tool-steel balls with a tempering range of over 500° C, obtained through the courtesy of Armstrong-Siddeley Motors Limited, enabled a few exploratory tests at higher temperatures to be carried out.

TABLE I.—*Tests on Diester Type Synthetic Lubricant to Specification D.Eng.R.D.2487.*

| Test No. | Load on upper ball, kg. | Temperature, ° C. | | Time to failure, minutes | Average time to failure, minutes | $t^{\frac{1}{3}}W$. |
|---|---|---|---|---|---|---|
| | | Start | Finish | | | |
| 1 | 600 | 202 | 197 | 8 | 8·6 | 1,229 |
| 2 | | 202 | 202 | 7 | | |
| 3 | | 202 | 206 | 5 | | |
| 4 | | 201 | 200 | 8 | | |
| 5 | | 202 | 202 | 10 | | |
| 6 | | 198 | 195 | 11 | | |
| 7 | | 195 | 192 | 11 | | |
| 8 | 500 | 203 | 202 | 13 | 14·3 | 1,214 |
| 9 | | 202 | 202 | 12 | | |
| 10 | | 202 | 203 | 13 | | |
| 11 | | 202 | 202 | 14 | | |
| 12 | | 201 | 197 | 17 | | |
| 13 | | 204 | 202 | 17 | | |
| 14 | 400 | 202 | 201 | 32 | 31 | 1,257 |
| 15 | | 201 | 198 | 32 | | |
| 16 | | 203 | 202 | 24 | | |
| 17 | | 202 | 206 | 28 | | |
| 18 | | 201 | 201 | 24 | | |
| 19 | | 201 | 205 | 27 | | |
| 20 | | 205 | 198 | 36 | | |
| 21 | | 204 | 199 | 36 | | |
| 22 | | 202 | 202 | 40 | | |

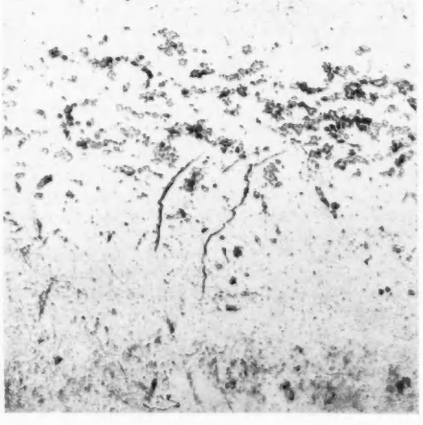


**Fig. 3 Fine transverse cracks in the bearing surface of a test ball—synthetic lubricant. (× 100)**

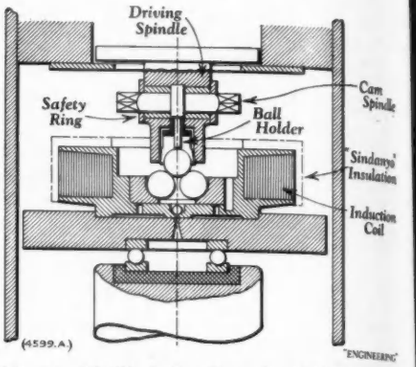



**Fig. 1 Modified Boerlage four-ball lubricant-testing machine incorporating a simple induction heater.**

### SYNTHETIC LUBRICANT (DIESTER TYPE)

Tests were carried out on the synthetic lubricant to Specification D.Eng.R.D.2487 (the lubricant currently used in turbo-jet and turbo-propeller engines) at various loads and temperatures to obtain sufficient data for comparison with other lubricants. Table I gives a summary of the results obtained at approximately 200° C.

The constancy of $t^{\frac{1}{3}}W$ (where $t$ is the time to failure and W the load) over the limited range of loads used indicated an inverse cube-law relationship.

The results of tests carried out under a constant load of 600 kg and at different temperatures are presented graphically in Fig. 2. The changes of temperature during the tests are indicated by the length of the horizontal lines. The arrow from 57° C indicates the average for 13 unheated tests, 57° C being the average temperature reached during these tests. It can be seen from the test results that increase of temperature reduces the time to pitting failure. This reduction of life appears to become significant above 160° C.

As no long-duration tests had been carried out to assess the effect of time at elevated temperatures on the lubricant, a sample of the oil

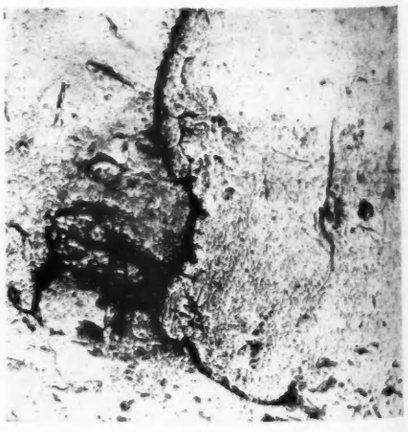


**Fig. 4 Well developed cracks and pit formation. (× 100)**

* Senior Experimental Officer, Lubrication and Wear Division, Mechanical Engineering Research Laboratory.

TABLE II.—*Tests on Synthetic Lubricant to Spec. D.Eng.R.D.2487 which had been maintained at 140° C for 14 hours.*

| Test No. | Load on upper ball, kg | Temperature, °C | | Time to failure, minutes | Average time to failure, minutes |
|---|---|---|---|---|---|
| | | Start | Finish | | |
| 1 | 600 | 203 | 209 | 11 | 10 |
| 2 | | 203 | 208 | 9 | |
| 3 | | 202 | 198 | 10 | |
| 4 | 400 | 204 | 203 | 41 | 46 |
| 5 | | 203 | 207 | 48 | |
| 6 | | 200 | 200 | 55 | |
| 7 | | 204 | 212 | 41 | |

was subjected to a treatment devised to simulate conditions in an engine. The sample, constantly stirred at 1,100 r.p.m., was maintained at 140° C for 14 hours. It appeared to darken in colour, and on standing a black precipitate settled out on the bottom of the container. The test results with lubricant after this treatment are given in Table II.

Heat-treatment of the lubricant does not appear to have increased proneness to cause pitting damage. The slight improvement as compared with the results shown in Table I may be due to the increase in viscosity which the oil suffered during ageing.

## GREASES AND OTHER LUBRICANTS

Two samples of grease were examined at 200° C, one an experimental silicone grease containing chlorine and intended for use in a wide temperature range from −55° C upwards, the other a lithium-base grease to specification D.T.D. 825. The test results are given in Table III.

From the test results it appears that the silicone grease incorporating a chlorine additive does not give as satisfactory a performance under the test conditions as the lithium-base grease.

Various types of lubricants and combinations of various types have been examined to assess the effect of these lubricants on failure at 200° C. The results are summarised in Table IV.

*Tests with Tool-Steel Balls.*—A few ½ in diameter etched tool-steel balls were used for exploratory tests, and a summary of the results obtained is given in Table V.

In the unheated tests the tool-steel balls appear to be slightly inferior to E.N.31 steel balls under the same conditions of test, but at 200° C appeared as good as E.N.31 steel balls. At higher temperatures, over 300° C, the tool-steel balls performed satisfactorily with dry molybdenum disulphide as the lubricant.

## EXAMINATION OF UPPER BALLS

Microscopic examinations of selected specimens from tests using different lubricants have been carried out to study in some detail the changes brought about by the test. After test, depending upon the nature of the lubricant, some bearing tracks remained bright; others presented a dull or etched appearance and some were very dark in colour, as if stained or covered with a film.

After test at 200° C with synthetic lubricant to specification D.Eng.R.D.2487, the bearing surface generally remained bright and displayed many features associated with balls run with

TABLE III.—*Tests on Greases*
Load on upper ball: 400 kg

| Test No. | Lubricant | Temperature, °C | | Time to failure, minutes | Average time to failure, minutes | Remarks |
|---|---|---|---|---|---|---|
| | | Start | Finish | | | |
| 1 | Lithium-base grease to Spec. D.T.D. 825 | 200 | 198 | 91 | 93 | Bearing surface and balls clean and bright |
| 2 | | 202 | 198 | 132 | | |
| 3 | | 203 | 202 | 70 | | |
| 4 | | 202 | 202 | 62 | | |
| 5 | | 201 | 206 | 113 | | |
| 6 | Experimental silicone grease containing chlorine | 205 | 183 | 34 | 36 | Balls dull with an etched surface appearance |
| 7 | | 204 | 188 | 35 | | |
| 8 | | 204 | 216 | 39 | | |
| 9 | | 205 | 209 | 35 | | |

TABLE IV.—*Tests on Various Lubricants*
Load on upper ball: 400 kg

| Test No. | Lubricant | Temperature, °C | | Time to failure, minutes | Average time to failure, minutes | Remarks |
|---|---|---|---|---|---|---|
| | | Start | Finish | | | |
| 1 | Typical conventional silicone | 201 | 205 | 28 | 36 | Considerable amount of wear on upper ball. Bottom balls dull |
| 2 | | 203 | 198 | 39 | | |
| 3 | | 203 | 211 | 32 | | |
| 4 | | 201 | 196 | 34 | | |
| 5 | | 200 | 198 | 37 | | |
| 6 | Experimental silicone intended for use from −55° C upwards. Contains chlorine | 203 | 206 | 21 | 23 | Normal pitting failure. Single small pit |
| 7 | | 204 | 202 | 29 | | |
| 8 | | 203 | 204 | 23 | | |
| 9 | | 202 | 194 | 20 | | |
| 10 | Suspension of $MoS_2$ in a soap-thickened silicone fluid. Lubricant formulated to combine the thermal and physical properties of a silicone with the lubricating potentialities of $MoS_2$ | 201 | 207 | 60 | 50 | Considerable amount of wear on upper ball. Bottom balls dull |
| 11 | | 203 | 200 | 41 | | |
| 12 | | 202 | 210 | 79 | | |
| 13 | | 202 | 198 | 49 | | |
| 14 | | 202 | 209 | 40 | | |
| 15 | | 204 | 204 | 34 | | |
| 16 | Experimental lubricant: 2 per cent graphite in a special mineral oil | 201 | 215 | 35 | 55 | Normal pitting failure |
| 17 | | 203 | 198 | 45 | | |
| 18 | | 201 | 201 | 69 | | |
| 19 | | 202 | 204 | 59 | | |
| 20 | | 206 | 200 | 66 | | |
| 21 | 10 per cent graphite in thin mineral oil base | 200 | 198 | 44 | 41 | Normal pitting failure |
| 22 | | 201 | 199 | 37 | | |
| 23 | | 200 | 192 | 41 | | |
| 24 | Dry graphite powder | 202 | 227 | 32 | 26 | Considerable wear and severe damage. Bottom balls black |
| 25 | | 205 | 209 | 22 | | |
| 26 | | 205 | 196 | 23 | | |
| 27 | Dry graphite powder with graphite-coated balls | 205 | 203 | 16 | | Bottom balls from tests 24, 25 and 26 used in these tests |
| 28 | | 200 | 203 | 23 | | |
| 29 | Dry graphite/lead oxide mixture 1:2 | 200 | 185 | 45 | | Considerable wear and damage. Bottom balls black |
| 30 | | 200 | 183 | 31 | | |
| 31 | | 199 | 208 | 33 | | |
| 32 | Dry molybdenum disulphide | 200 | 220 | 147 | | Considerable wear. Badly damaged |
| 33 | | 200 | 188 | 74 | | No failure |
| 34 | | 204 | 204 | 86 | | Considerable wear—no pits |
| 35 | | 200 | 186 | 148 | | No failure—considerable wear |
| 36 | | 202 | 212 | 36 | | No failure—some wear |
| 37 | Molybdenum disulphide in paste form with a mineral oil carrier | 203 | 214 | 163 | 135 | Normal pitting failure |
| 38 | | 203 | 209 | 112 | | |
| 39 | | 205 | 203 | 102 | | |
| 40 | | 202 | 200 | 132 | | |
| 41 | | 205 | 199 | 150 | | |
| 42 | | 206 | 207 | 149 | | |

A summary of the performance of these lubricants, unheated, is given in reference 4.

**Fig. 5 Roughened, cracked surface of test ball—dry graphite lubricant. (× 100)**

**Fig. 6 Partially-removed surface film on the bearing track after test with $MoS_2$ (× 100)**

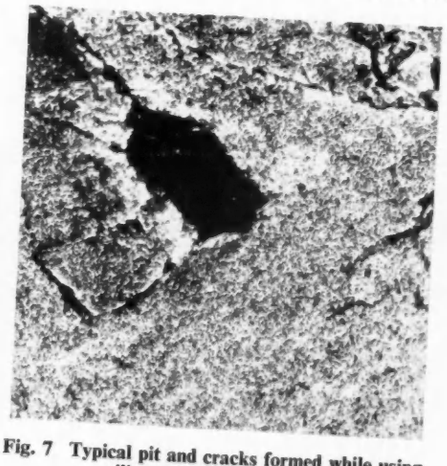


**Fig. 7 Typical pit and cracks formed while using silicone grease. (× 100)**

## *Continuing* Research and Development

TABLE V.—*Tests with Tool-Steel Balls*

| Test No. | Conditions of test | Lubricant | Load, kg | Temperature, °C | | Time of test, minutes | Average time of test, minutes | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | Start | Finish | | | |
| 1 | Unheated .. | Synthetic lubricant to Spec. D.Eng. R.D.2487 | 600 | 17 | 50 | 28 to failure | 24½ | Normal type of failure—one pit |
| 2 | | | | 17 | 42 | 27 to failure | | |
| 3 | | | | 20 | 42 | 15 to failure | | |
| 4 | | | | 17 | 40 | 28 to failure | | |
| 5 | Elevated temp. | ,, ,, | 400 | 198 | 203 | 37 to failure | — | Normal failure, one pit |
| 6 | | | | 200 | 215 | 63 to failure | | |
| 7 | Elevated temp. | Dry molybdenum disulphide | 400 | 300 | 310 | 30, no failure | — | — |
| 8 | | | | 310 | 330 | 70, no failure | | |

mineral oils unheated.[1] Fine transverse surface cracks were found, which appeared to develop, causing removal of surface material and initiating pitting failure. Fine transverse cracks in the bearing surface of an upper ball after 7 minutes running under heavy load—600 kg (corresponding to a nominal maximum Hertzian stress of about 500 tons per sq in)—are shown in Fig. 3 (× 100). Fig. 4 (× 100) shows well-developed surface cracks under similar test conditions. A small surface pit is partially formed and appears to be in process of expanding.

The lower balls from tests using dry graphite were black and shiny in appearance as if covered with a "graphoid" layer. The bearing tracks of the upper balls were dark and appeared to develop fatigue cracks and pits and become rough in appearance due to the removal of surface material, as shown in Fig. 5 (× 100).

The bearing surface of balls from tests using molybdenum disulphide in paste form in a mineral-oil carrier was generally dark and had an etched appearance. Occasionally the track appeared to be covered by a dark grey film.

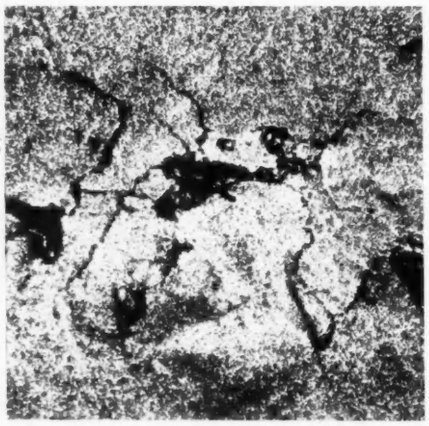


**Fig. 8 Continuous type fine pitting. (× 100)**

Brisk polishing on a Selvyt cloth removed the film in places, as shown in Fig. 6 (× 100). The normal surface of the ball adjacent to the track can be seen at the top of the photomicrograph and the partially-removed film reveals an etched bearing surface. The polishing scratches in the film suggest that it is soft and easily deformed.

With the silicone grease containing chlorine, considerable wear was experienced and the bearing surface appeared to deteriorate by continuous fine pitting. The area shown in Fig. 7 (× 100) is typical of the track; it has an etched appearance with all pits expanding by rapidly propagating cracks. Fig. 8 (× 100) shows the effect of the suspension of molybdenum disulphide in a soap-thickened silicone fluid. The small surface pits in process of expanding were a typical feature of breakdown and rough running.

When using dry molybdenum disulphide, the lower balls ranged from being slightly dulled to almost black in appearance. The bearing surface of the upper balls appeared almost black after the shorter tests but only dull and rough after prolonged running. It appears that a dark surface film is formed but eventually disintegrates causing continuous fine pitting or removal of surface material with subsequent wear and rough running. Fig. 9 (× 100) shows the bearing surface of an upper ball after 85 minutes' running when some noise was developing. Cracks and irregularities are beginning to cause roughness.

### EXAMINATION OF LUBRICANTS

Some of the lubricants underwent changes during test at elevated temperatures. The silicone grease darkened and the small amount of grease subjected to mechanical working in the region of maximum rolling and sliding turned almost black. The lithium-base grease was fluid during test, and at the conclusion of the test had changed from its original straw colour to a brownish colour; on cooling it appeared slightly thicker in consistency and in some instances to have a fibrous rubbery appearance. Electron-microscopic examination of the grease before and after test revealed that the fibre structure had undergone changes as shown in Fig. 10 (× 20,000). It is to be noted that the grease of fibrous, rubbery appearance after test displayed larger fibres. This is due to the heating and cooling action as mechanical working in a bearing causes breakdown of fibre structure.[2]

TABLE VI

| Lubricant | Condition of lubricant | Strong acid no. | Total acid no. |
|---|---|---|---|
| Synthetic lubricant to Spec.D.Eng.R.D. 2487 | Unused .. .. | Nil | 0·1 |
| ,, ,, | After 40 minutes' test run at 200° C | 0·05 | 0·2 |
| ,, ,, | After 14 hours at 140° C | 0·03 | 0·42 |
| Conventional silicone | After 30 minutes' test run at 200° C | 0·03 | 0·50 |
| Experimental silicone containing chlorine | Unused .. .. | Nil | Nil |
| ,, ,, | After 4 minutes' test run at 200° C | 0·1 | 0·42 |
| ,, ,, | After 21 minutes' test run at 200° C | 0·09 | 0·70 |

The liquid silicones generally changed first by the appearance of a fine flocculent material. This appeared to concentrate and turn brownish, in the case of the straight silicone, but greenish-brown in the case of the experimental silicone containing chlorine. As the test proceeded the silicone lubricants continued to darken and at the conclusion of most tests were black liquids. The acidity of various lubricants was checked before and after test at 200° C and the results are given in Table VI.

The changes in acidity are really very slight, but it may be noted that the silicone lubricant containing chlorine quickly became slightly acid and, after prolonged test, although the total acid had increased the strong acid was less, possibly due to neutralisation by attack of the bearing surface.

### MOLYBDENUM DISULPHIDE BENEFICIAL

Molybdenum disulphide in paste form with a mineral oil carrier gave good results, and the results with dry molybdenum disulphide seem encouraging. With the latter, failure was due not to the usual sudden appearance of a surface pit but to progressive surface roughening. Molybdenum disulphide appeared to improve the performance of silicone-type lubricants from the pitting aspect, but with this type of lubricant considerable wear of the bearing surface was usually experienced. As a solid lubricant, graphite containing a preponderance of the conventional Bernal graphite was not as effective as molybdenum disulphide. Similar results for sliding tests at temperatures below 1,000° F were reported by Peterson and Johnson.[3] These workers found that mixing graphite with a soft

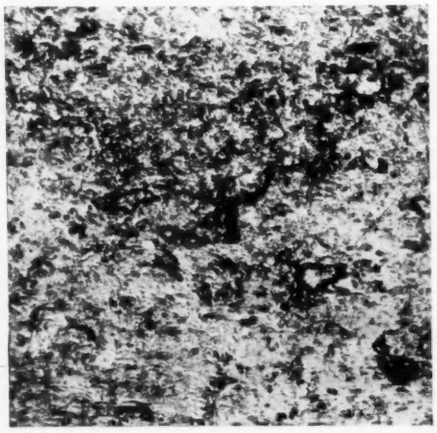
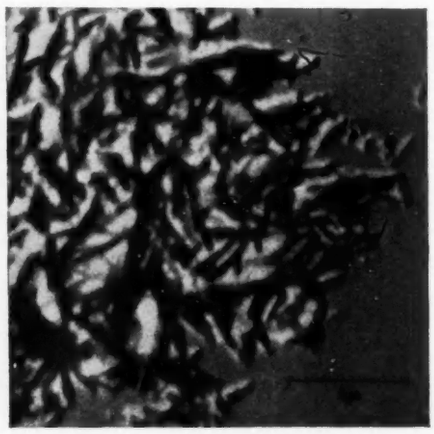


**Fig. 9 Roughened surface of ball from noisy bearing. (× 100)**



**Figs. 10 and 11 Fibre structure of lithium-base grease before and after test. (× 20,000)**

# GOVERNMENT RESEARCH REVIEWED

*By The Earl of Halsbury*, F.R.I.C., F.INST.P. *Managing Director, National Research Development Corporation, London*

It is often asked whether the Government machine for administration of scientific research is conceived along the right lines or whether it stands in need of any drastic reform. I can only write of those parts of it with which I am familiar, particularly the Department of Scientific and Industrial Research. There are other branches of Government research, such as those sponsored by the Colonial Office, with which I am unfamiliar. In writing of DSIR, my comments exclude any consideration of its grant-aiding activities, which are considerable.*

It is easy to find critics of a type who are permanently "agin" any established institution whatever it may be. This is particularly so in Britain where we have a masochistic urge to decry our own way of doing things come hell or high water. As I do not share this urge, I am not disposed to quarrel unduly with the Governmental machine for scientific administration. It is not perfect, but it could be a lot worse. Like all evolutionary products it is not easy to take in at a glance and it is easier to misunderstand than to comprehend it.

In order to remove misunderstanding, I will therefore state three theses which I am prepared to defend, namely: (*a*) That some of its faults are universals, characteristic of machines; (*b*) That others are universals, characteristic of governmentalism; (*c*) That its more specific shortcomings are consequences of the fact that the machine is in a state of continuous evolution; that is to say, that at any one moment it is incomplete. Rectifying such shortcomings is the regular concern of a large number of councils and committees who appear to have all the powers they need for their work.

If these contentions are accepted, then the fight against shortcomings of the first two types will never be completely victorious, while shortcomings of the third type call for no revolutionary reform.

Assuming that no machine existed and that one were to build it from scratch, what reasonable chain of responsibility would one consider as a starting point? It would be reasonable to suppose that technical Ministries (Supply or Post Office or Power, for instance) would have their own scientific administration and that the remainder of the Government scientists should be grouped under a single Minister. Remembering that the cost of Government science is small both in relation to its importance and the Chancellor's budget, there are good arguments for making it the part-time responsibility of a senior member of the Cabinet rather than the whole-time responsibility of a junior member thereof. The Prime Minister, Chancellor, Home Secretary and Foreign Secretary are very heavily loaded with responsibilities. The Lord President of the Council is usually a very senior Cabinet Minister and relatively free from departmental cares. His selection as the Minister to be responsible would seem reasonable and have much to recommend it. It was, in fact, the historical choice.

## LORD PRESIDENT'S FUNCTION

There remains for consideration the important question of how to define a technical Ministry, i.e., of how to select those branches of scientific administration which should *not* be grouped together under the Lord President. In broad terms, should hypothetical policy be to maximise or minimise the Lord President's function? Historically the tendency has been to maximise it. It is therefore reasonable to look at the alternative. The opposite policy would have assigned the Medical Research Council to the Ministry of Health, the Agricultural Research Council to the Ministry of Agriculture, Fisheries and Food, and various establishments, at present the responsibility of the Department of Scientific and Industrial Research, to various other ministries, such as the Fuel Research Station to the Ministry of Power, the Road Research Laboratories to the Ministry of Transport, the Building Research Station and the Fire Research Station to the Ministry of Housing, and so on. Such a grouping would not be unreasonable prima facie, and would leave DSIR with about seven out of its present fourteen stations. Some of the Ministries mentioned above are not technical in the sense that Supply is technical, but it could be argued that they would become so if they were responsible for their own research. I personally doubt this.

There are, however, at least as many arguments against minimisation as for it, and almost no arguments for making any major change at this late date. The fact that the Medical Research Council is *not* responsible to the Ministry of Health, for example, gives it a robust independence which prevents the Ministry acquiring an intellectual monopoly in medical matters. Whatever faults in the Government machine may be alleged, I know of none that would be cured by such a transfer of responsibility. In fact the tendency in agricultural research, for example, has been for transfer to take place in the reverse direction. Much of the work of Government scientists involves interdepartmental committee work and this is facilitated by maximising their grouping under one Minister. They do at least form a single strong group with all the possibilities for good, latent in unified leadership, and the growth of an esprit de corps. The machine, therefore, is not ill conceived.

What then are the faults alleged? One allegation is made indifferently by critics of both Government and industrial science alike, namely that it costs a lot and the results are exiguous. I have listened to distinguished industrialists making this complaint about their own laboratories. One such, the managing director of his group, complained to me that it had spent a million pounds on research which produced almost nothing. Inquiry elicited the fact that it had done very little research at all. Most of the money had gone on "trouble-shooting" for customers. Regarded as sales promotion, costing one per cent of turnover, however, it was probably money well spent. The sense of disappointment arose from misunderstanding based on misdescription. Large organisations tend to forget why they start things and blame their executives for doing no more than complying with their terms of reference. A great part of the money spent (and well spent) by DSIR is not intended to produce either inventions or discoveries, and never will.

## RESULTS OF RESEARCH

Standardisation procedure at the National Physical Laboratory, reports on new building materials and techniques from the Building Research Station, the collation on a national scale of all drilled rock cores by the Geological Survey—one can reel off an apparently endless list of similar activities managed and maintained by DSIR as national services. I once made an approximate calculation which indicated that about half of all the money spent by the Department on its establishments issued in information of this character, important information, information demanded pre-emptively by people eager to use it, but such as to issue in results only indirectly and rarely in spectacular form.

The output of the universities is creative, I suspect, just *because* it is undirected and is the product of the freely operating human imagination. Directed creativity is to some extent a contradiction in terms. Many who complain that applied research is expensive and unrewarding are, I think, voicing their disappointment with the above basic fact in hyperbolic terms. Those who express disappointment at the utility of the results of Government research do so, I believe, because they expect the wrong

* Lord Halsbury wrote this article before the recent publication of *DSIR: Report of the Research Council for the year* 1956-57 (Cmnd. 428, 4s.), which is the subject of this week's leading article.

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## *Continuing* Lubricants at Higher Temperatures

metal oxide gave effective lubrication from room temperature. Experiments in which graphite was mixed with lead oxide (1 to 2) showed some improvement when tested in the apparatus described here, but it was not so effective as graphite in mineral oil. Previously-used bottom balls, apparently graphite covered, gave no significant improvement. It thus appears that the method of bonding graphite to the surface is important in each different application. Some method of keeping the dry lubricant constantly fed into the contact area could be an advantage, while feeding of lubricant to the critical areas would also appear to be beneficial with grease lubrication. Microscopic examination of selected specimens has revealed surface changes brought about by the test and afforded some insight into the mechanism of failure.

From the few preliminary test results with high-speed tool-steel balls it appears possible that the temperature range of the test could be extended up to the tempering temperature of the balls, 500° C. Closed-circuit lubrication for liquids, and controlled atmosphere and mist lubrication with solid lubricants, may be necessary for higher temperature tests and modifications to accommodate these types of lubrication could be effected without sacrifice of the simplicity of the test procedure and specimen.

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### ACKNOWLEDGMENTS

The work described has been carried out in the Lubrication Division of the Mechanical Engineering Research Laboratory under the general guidance of Dr. F. T. Barwell, head of the Division, and is published by permission of the Director of Mechanical Engineering Research, Department of Scientific and Industrial Research. Acknowledgment is made of helpful discussion with colleagues in the laboratory and of experimental assistance afforded by Mr. T. D. Cain and Mr. J. I. Stevenson.

*Continuing*

## Research and Development

things in the first place. A great deal of the Government's output takes the form of information required for the research of others.

As to the remainder, success in the field of applied research depends on a flair for selecting good targets. This is clearly a personal characteristic of research directors. It is a rare quality and it is open to any critic to assert that he could do better than someone else. This article, however, is concerned with *system* and no reform of machinery or system can make a man improve his target selection if he isn't disposed to do so; if he is so disposed, a good system can of course be a help.

When critics are brought face to face with the above arguments, they frequently react by proposing a change in terms of reference, only to find that this is both controversial and formidably difficult. Once terms of reference have been written and an organisation has evolved during thirty years in order to give them effect, it is extremely difficult to "pull it into reverse" and launch it in a new direction. Everything turns out to be wrong for the new proposal, and every man the wrong man for the new job. Size plays a most important role in this respect. The larger an organisation is, the more difficult is it to give it a reorientation in opposition to the many serious-minded people who do not agree with the view that it needs reorientating. A Government machine is no different from an industrial machine in this respect. There are certain machine faults which are universals; they will not be made to disappear because the machine is a governmental one.

### TREASURY'S FIGHT

Other universal faults are governmental. It is easy to treat the Treasury as the villain of every piece, but their critics rarely seem to try and understand the Treasury's problem. They are responsible for an enormous organisation, the Civil Service, in charge of a colossal expenditure. Everyone can find wonderful reasons for increasing expenditure in whatever direction his personal interest happens to lie! The Treasury is the sole force in the country engaged in a permanent fight to reduce it. A condition essential for the success of their struggle is that the system should be simple enough for mortal man to understand it in view of the scale on which it operates. Simplicity and homogeneity are therefore cherished objects of public administration. This leads to certain classes of unavoidable absurdity—unavoidable, that is, if one grants the premises of the argument. Whatever is regarded as proper in the way of Government activity, changes progressively in accordance with circumstances and public opinion.

Historically, the range of what is regarded as proper activity has grown. As each new activity is recruited into the governmental orbit, pressure is brought to bear to "uniformise" its administration along the lines of a framework originally designed for earlier purposes. In this sense Government science is not administered as it probably would be if it were non-governmental or if all the nation's administration were concerned with science. This argument does not select the scientific machine for specially severe treatment; it would, I suspect, be applied to *any* form of administrative deviationism. One can sympathise with it while regretting the sacrifice of the part to the whole, particularly in the context of science.

After conceding the faults of machines and the faults of governmentalism, what remains for reform, apart from the faults of individuals which it is not my remit to discuss? There remain, I think, certain ambiguities of purpose which require resolution though no very obvious solution can be postulated. Granted that such topics as research into building, fire prevention, forest products, water pollution, geology, road construction, pest infestation, and hydraulics should be undertaken at the public expense, it is not unduly difficult to decide what sort of research should be undertaken.

Apart from standardisation, it is *not* obvious what the National Physical Laboratory and the Chemical Research Laboratory at Teddington, or the Mechanical Engineering Research Laboratory at East Kilbride ought to be doing. Their titles cover fields so vast, and in a sense so diffuse, that they give no clue as to what sort of selection their boards should make from among the innumerable topics in their fields. I do not believe, however, that resolution of these ambiguities would have the character of a revolutionary reform. It is easy to say that they ought not to be doing what they are doing, but something else. It is less easy to get any two critics to agree as to what else they should be doing. Some critics seize on this point and argue that in such a case there can be little justification for their existence at all in their present form. Again the difficulty lies not in conceding that the critics have made a point but in getting a sufficient weight of informed opinion to assent to it as a good one. Most people simply disagree.

Such problems are common to all advanced democratic countries. It seems worth recording that among foreign scientific administrators the British Government's machinery is regarded as an object of envy. We don't therefore need to give rein to our national passion for crying "stinking fish."

### DSIR ADVISORY COUNCIL

The most important administrative reform of recent years was the conversion of the DSIR Advisory Council into an executive body. The effects of this have yet to be felt. Having attended a number of meetings where this reform was explained and expounded, I was left with the impression that few audiences understood the constitution of the Council that was being reformed, and the nature of the activities for which it was responsible. In fact the machine for which the Lord President is responsible (DSIR, ARC, MRC and Nature Conservancy) is tricky to understand except for those who are concerned with its administration. Like our system for financing education, it cannot be easily explained on a sheet of notepaper with the aid of a conventional "responsibility" chart. The only satisfactory way to learn it is to work with it. Some proposals for reform to which I have listened from time to time appear designed less to improve the machine from the administrative angle than to render it more readily explicable to the casual inquirer. Evolution and growth always undo such reforms, which can therefore serve only transient purposes.

My conclusion then is that there is nothing *basically* wrong with the machine. It creaks where all machines creak and where all governmentalism creaks. If it appears to behave worse than it should after all allowances have been made, it must be because individuals drive it less than perfectly. As the philosopher said: "Perfection is finality; finality is death; nothing is perfect; there are lumps in my porridge."

# SUCCESSFUL TRIALS OF AUTOMATIC LANDING EQUIPMENT

*The brief description given below of developments in completely automatic aircraft approaches and landings now under way at the Royal Aircraft Establishment, Bedford, is an extract from the 46th Wilbur Wright Memorial Lecture, on "Automatic Flight—The British Story," given recently by the director of RAE, Dr. G. W. H. Gardner, C.B., C.B.E., before the Royal Aeronautical Society. The lecture covered the development of automatic flight control in Britain from Sir Hiram Maxim's first proposals, in* 1891, *up to the present day, and including a brief consideration of weapon guidance.*

Air transport completely independent of weather conditions has yet to be achieved, but automatic pilots are being used more and more to enable aircraft to operate with regularity and safety in adverse weather. Low cloud and poor visibility in the terminal area are still limiting factors, but their effects are being reduced by the use of automatic approach. Both civil and military operators are now using auto-pilots which enable automatic approaches to be made in conjunction with the radio approach aid I.L.S. (instrument landing system) down to a height of about 200 ft.

The most important factor which limits the height down to which automatic approach can be used is the finite time which must be available for the visual transition and landing. This in turn is affected by aircraft approach speed, lateral manoeuvrability, downward view from the cockpit, width of runway, and length and type of approach-lighting pattern. One possible way of overcoming this critical problem is by extending the automatic-approach technique to touchdown and possibly beyond, i.e., automatic landing.

The I.L.S. position information is unsuitable for landing and it is necessary, therefore, to provide supplementary methods to cover the landing manoeuvre from a low height on the approach to a point at which the aircraft may taxi with safety.

### RAE SYSTEM

In one such system in course of development at the Royal Aircraft Establishment, an automatic I.L.S. approach is made to a low height, when the I.L.S. inputs to the auto-pilot are switched automatically; the localiser signal is replaced by a magnetic leader-cable signal, and the glide-path signal by a radio altimeter signal. Leader-cable guidance is provided as far along the runway as necessary to cover the aircraft ground run, and may be extended to cover the taxi-ing of the aircraft. The radio-altimeter information is used to reduce the rate of descent by controlling a flare-out on to the runway. Control of throttle is also programmed to reduce the engine thrust on the flare-out, and just before touch-down any drift due to crosswind is automatically removed. Once on the ground, automatic control can be disengaged and the aircraft brought to rest manually. The pilot is assisted by steering instructions presented on a flight detector which forms part of the fully integrated instrument and automatic-control system. Numerous safety features and confidence checks have been built into the system to guard against failures, and the whole operation can be monitored by the pilot on the flight director.

During the past three years, aircraft attached to the Blind Landing Experimental Unit at RAE have made over 450 landings under automatic control, 400 in a Varsity and 50 in a Canberra. In some landings, manual control of throttle was exercised, but in all cases all flying controls were operated automatically; 125 of the 450 landings were made during February this year without any trouble or adjustments. These landings have been supported by over 1,150 touch-downs made with only partial automatic control: for example, control in one plane only, or an automatic flare-out to a datum a few feet above the runway. Of these 1,150, 800 have been made in a Varsity and 350 in a Canberra. The aircraft have suffered no damage in making these 1,600 partial, or completely, automatic landings. It is suggested that this is a most important and encouraging pioneering achievement.

**Construction**

# UNUSUAL DOORS FOR BOAC MAINTENANCE HANGAR

Travellers along the Great West Road extension in recent months will probably have observed, as they passed London Airport, the rather strange sight depicted in the accompanying illustration—the tail of one or more Britannia airliners protruding from what appears to be holes cut in the hangar wall. This is not, as some have surmised, the result of an error, on the part of BOAC's constructional engineers. It is, on the contrary, a deliberate policy in the interests of economy.

Since most of the routine checks and maintenance required by to-day's airliners are carried out on the forward part of the machine, and since economy of operation is as important in air transport as in any other business. British Overseas Airways Corporation have recently introduced the "wing hangar" at London Airport. This development, which is new to Britain, encloses only the forward portion of each aircraft, leaving the whole of the tail unit protruding, thus economising on hangar space and the cost of building. By having sliding doors recessed to embrace the fuselage, the hangar can be completely enclosed while work on the aircraft proceeds.

**On each side of BOAC's wing hangar there are 24 aluminium-clad steel-framed doors; 10 are motorised and 6 have tail enclosure apertures, as shown here.**

The doors themselves are of interesting design and provide an unusual example of metal fabrication. There are 48 altogether, 24 on each side of the hangar, which is bisected by a central dividing service hall; ten of the 24 are motorised and six are made with a suitable aperture for the tail enclosure unit.

Each door is 32 ft high, 23 ft 6 in wide and 1 ft thick and is provided with generous windows; a wicket door is provided in each of the motorised doors. The doors forming the tail enclosure units are fitted with flexible fabric gaskets to seal the gap between the doors and the fuselage, and yet permit the aircraft a fair degree of movement during servicing. When these units are not in use the apertures can be closed by hinged flaps.

The guide wheels run in brackets fitted to the top of the door frame and the main wheels are housed in a fabricated chassis forming an integral part of the frame. The chassis of the motorised doors is strengthened to carry a 2 h.p. electrical power unit, fluid drive and clutch mechanism.

The framework of each door is constructed of steel channel section 12 in by 3½ in by 10 s.w.g., cross-braced with a similar section but with holes to reduce the weight; use is also made of lattice-type members. The whole assembly was electrically welded. To facilitate handling, the framework was constructed in three sections which were bolted together using gusset plates slotted through the main channels, the connections being made with $\frac{5}{8}$ in high tensile bolts. Before cladding, the framework for the unmotorised doors weighed only 1¾ tons.

Cladding is of aluminium: Noral Mansard sheet 0·036 and 0·028 in thick is secured to both sides of the framework by pop rivets and an extruded "top-hat" section in Noral B51SWP alloy is used to cover the bolt heads so as to give a neat finish. To prevent reaction between the steel and the aluminium, the framework was given phosphate treatment followed by a zinc chromate dip, and, in addition, the aluminium surfaces that were to make contact with the steel were coated with a bituminous paint. Aluminium, in the form of flat sheet in Noral 3S alloy, half-hard, in thicknesses ranging from 0·064 in to 0·125 in, was also used for cladding the wicket doors and the hinged flaps that cover the fuselage aperture when required.

It is estimated that the assembly of each door required altogether about 450 ft of welding, which was used not only for the main framework but also for the attachment of glazing bars, cladding stiffeners and other parts. Welding and the work of assembling the three sections had to be precisely done because close tolerances were specified throughout (for example, the overall frame was to be $\pm \frac{3}{16}$ in dead flat); special jigs were therefore used, and the whole unit was squared-up before clamping and reaming the assembly bolt holes.

The size of the doors raised further difficulties in fabrication, transport and erection. To enable the whole 32 ft by 23 ft 6 in framework to be turned over after cladding had been completed on one side, a special jig was constructed capable of allowing the frame to swing completely over while suspended from the 40 ft jib of a mobile crane; to prevent overturning, the jib itself was back-stayed to two concrete blocks sunk in the ground.

Transport was difficult because although the works of the fabricators, Morfax Limited, are situated at Feltham, little more than a mile from London Airport, the doors were a few inches wider than the road at some points and while they were being transported in the flat, supported by a special bolster, the lorry had to "zig-zag" between the staggered lamp-posts. Due to the enormous overhang it was necessary to travel at a very slow speed on all parts of the route.

Erection was difficult because the roof of the hangar, taking the form of a cantilever of 116 ft span, would not allow the suspension of any fairly heavy load from its free extremity; moreover, since the doors are, in some measure, of stressed-skin construction, there were few points at which they could be lifted. These difficulties were resolved by first supporting the head-box structure, containing the guide beams, on steel poles and then raising the door by means of hand-driven winches, with chains attached to temporary lugs secured to the top of the door, and a fork-lift truck using a special attachment secured to the bottom. In this way the door was manoeuvred on to its rail track, then the lifting lugs were removed and the guide wheel brackets attached.

**The tail aperture closing flaps are operated by a cable winch built into the doors. When aircraft are being serviced, flexible fabric gaskets seal the gap between the doors and the fuselage.**

The completed doors, weighing about 3 tons each, move easily on their tracks, one man having no difficulty in propelling three of them coupled together. This is due both to the precision of the assembly and also to saving weight as far as possible by the extensive use of welding and the application of aluminium for all but the structural members. Altogether some 24 tons of aluminium, averaging about half-a-ton for each door, were supplied. A further advantage of the use of aluminium is that it will last for very many years, without the need for painting or other maintenance.

The consulting engineers were Bernard L. Clark and Partners, who designed the doors in co-operation with Mr. L. B. Haley, Chief Civil Engineer to the British Overseas Airways Corporation. Morfax Limited, Mitcham, Surrey, the contractors for the fabrication of the doors, were also responsible for erection and electrical installation. The aluminium cladding was supplied by the Northern Aluminium Company, Limited, Banbury, Oxfordshire.

**A "Construction" Letter**

# ACCELERATED CURING TESTS ON CONCRETE

SIR, I should like to refer to the very interesting article on this subject by Mr. N. N. B. Ordman and Dr. N. G. Bondre (ENGRG. 21 Feb., '58, p. 243) and the ensuing correspondence.

It appears that there are three methods of accelerated curing. Firstly, the steam curing method developed by Nurse and Saul in another connection and referred to by Professor J. W. H. King in his letter to you on p. 164 of your issue of 6 April, 1956 (" a container constructed on the lines of the old-fashioned steamer where the cubes are in a dry chamber but almost completely surrounded by a steam jacket "). Secondly, there is the oven curing method described by Professor King in the *Chartered Civil Engineer* of November, 1955 (p. 46), and, thirdly, the method of curing in boiling water described by Mr. R. G. Smith-Gander and myself in an article in your issue of 17 February, 1956 (p. 153). In the first and third methods, there is no possibility of the cube drying out during curing and, with fully compacted cubes, there is no change in the original water/cement ratio. In the oven curing method, there is no possibility of a change in the original water/cement ratio, but it might be considered that the cubes could to some extent dry out, and Professor King has suggested this possibility as a hypothesis to account for the definite decrease in strength when curing in an oven above 90° C, although he does not consider it likely and in this view he is no doubt correct.

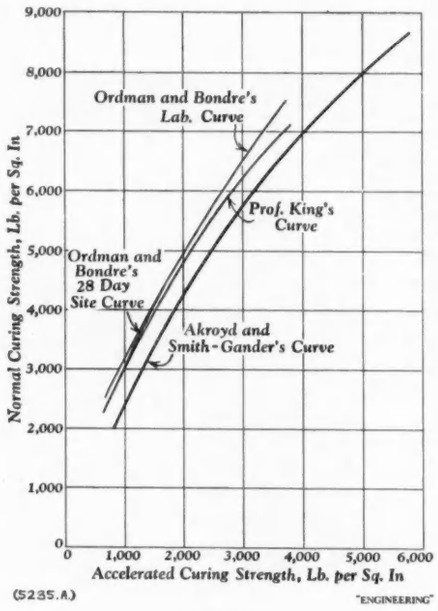



**Fig. 1**

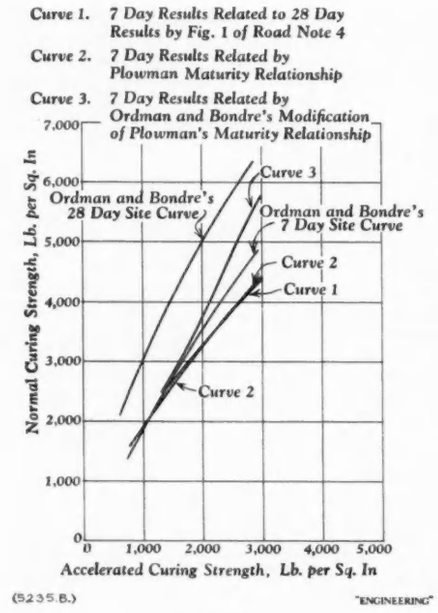



**Fig. 2**

From Fig. 1 attached, it will be seen that there is a difference between the curve determined by Professor King and that determined by Smith-Gander and myself. It may be that a clue to the explanation of some of the difference is contained in recent correspondence in your journal, which indicated that, due to the difference in ovens, modification of the heating cycle or temperature may be necessary to bring the results into line with those of Professor King. It appears that different ovens can give different temperature gradients across the oven, depending upon the type of oven and the spacing and type of heating element.

As I have reported elsewhere (*Laboratory Testing in Soil Engineering*, by T. N. W. Akroyd, Soil Mechanics Limited, London, 1957) the variation of temperature across the oven can be of the order of 40° C and Professor T. W. Lambe has indicated (*Soil Testing for Engineers*, by T. W. Lambe, John Wiley and Sons, New York, 1951) that even larger temperature gradients may be experienced. It is essential, in my opinion, in using the oven technique to ensure that a well designed electric oven is used, and attempts to use ovens such as the domestic gas oven described by Mr. Robert Humphreys (ENGRG. 21 Mar., '58, p. 355) may not always meet with success.

Referring now directly to Mr. Ordman and Dr. Bondre's article, it is interesting to plot the 28 day results of both their laboratory and site work on the same graph as Professor King's curve. This is shown at Fig. 1. Since these three curves are all slightly different, I suggest that it is necessary, on any particular site, to establish directly the curve relating accelerated cured strengths and normally cured strengths for that site, and, in fact, this is the procedure we are adopting for our boiling technique. On the other hand, comparing the various curves and the scatter of the results, it may be suggested that the variation in the curves is less than the scatter, particularly for Ordman and Bondre's two curves, and it might be unnecessary in practice to use the Plowman maturity relationship, referred to by Ordman and Bondre, in work on the accelerated curing tests.

In connection with Ordman and Bondre's modification of the Plowman maturity relationship, I have plotted in Fig. 2 a number of different curves. First of all there is plotted their 28 and 7 day curves from Fig. 4 in their article, i.e., the site curves. Assuming that one were to carry out a series of tests, in which the accelerated strength and the 7 and 28 day strengths were obtained, from a batch of cubes cast from the same mix, as is usually done in establishing the curves of accelerated strengths against normally cured strengths, and accepting the 28 day curve as given by Ordman and Bondre as a basis, then corresponding 7 day curves can be plotted, depending upon the relationship between the normally cured 7 day strength and 28 day strength.

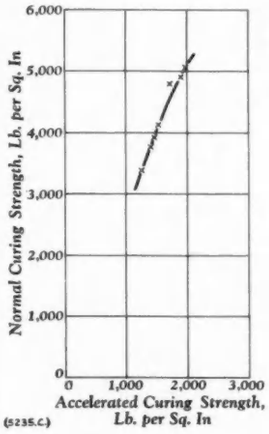



**Fig. 3**

Three curves have been plotted by me. The first assumes that the 7 and 28 day relationships, as given by Fig. 1 in Road Note 4, holds good; the second is based on the Plowman maturity relationship as given by him in his paper (" Maturity and the Strength of Concrete," by Dr. J. M. Plowman, *Concrete Research*, Mar. '56, p. 13) and is close to the first curve; the third curve uses the constants A and B suggested by Ordman and Bondre in Table III of their article. Table I, attached, sets out the accelerated curing strength from the Ordman and Bondre 28 day site curve, together with the 7 day strengths corresponding to the 28 day strengths from Fig. 1 of Road Note 4. In Table II, the 7 day strengths corresponding to the 28 day strengths are calculated by means of the Plowman maturity relationship, and, in Table III, the 7 day strengths shown are those calculated by means of Ordman and Bondre's modification of the Plowman maturity relationship.

Comparing these curves with the actual experimental results obtained by Ordman and Bondre, it appears that the relationship between 7 and 28 day strengths, as expressed by Road Note 4, does not always hold good. In fact, it is known

TABLE I.—*All figures in lb per sq. in.*

| Ordman and Bondre's accelerated site test results | 28 day strength | Road Note 4. 7 day results corresponding to 28 day results |
|---|---|---|
| 2,600 | 6,000 | 4,000 |
| 2,350 | 5,500 | 3,700 |
| 2,050 | 5,000 | 3,250 |
| 1,750 | 4,500 | 2,900 |
| 1,475 | 4,000 | 2,500 |
| 1,225 | 3,500 | 2,200 |
| 1,000 | 3,000 | 1,900 |
| 750 | 2,500 | 1,600 |

TABLE II.—*All figures, except constants and percentages, in lb per sq. in.*

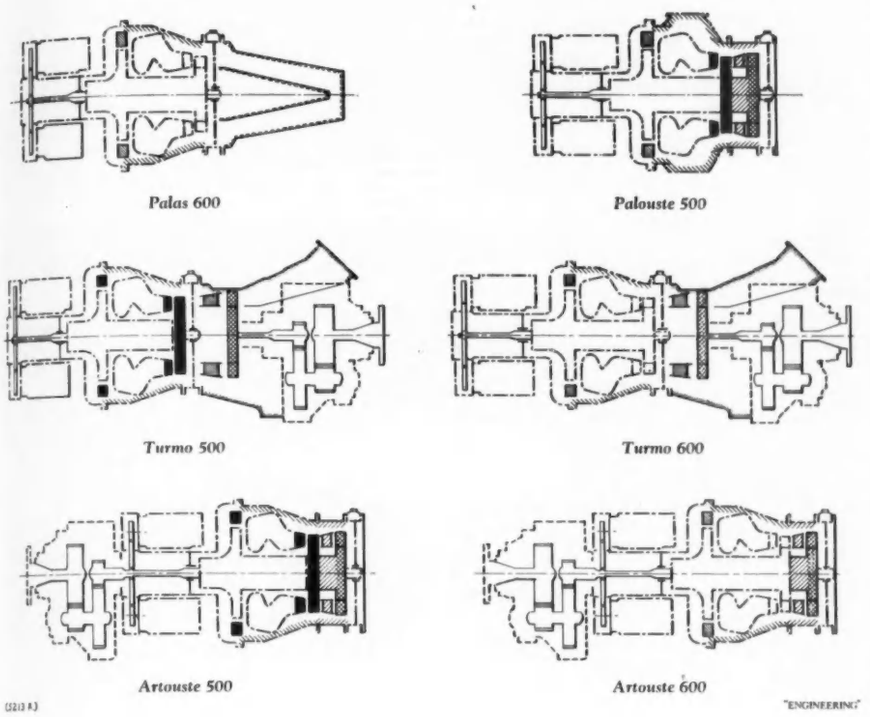
| Ordman and Bondre's accelerated site test results | 28 day strength | 7 day strengths corresponding to 28 day results from Plowman maturity relationship | | | |
|---|---|---|---|---|---|
| | | Constants | | Per cent of 28 day | 7 day |
| | | A | B | | |
| 3,000(?) | 6,500 | 19 | 52 | 68·3 | 4,400 |
| 2,480 | 5,770 | 15 | 55 | 67·1 | 3,880 |
| 2,050 | 5,000 | 11 | 58 | 66·0 | 3,300 |
| 1,650 | 4,300 | 10 | 60 | 66·9 | 2,870 |
| 1,400 | 3,800 | 8 | 62 | 66·8 | 2,540 |

TABLE III.—*All figures, except constants and percentages, in lb per sq. in.*

| Ordman and Bondre's accelerated site test results | 28 day strength | 7 day strengths corresponding to 28 day results from Ordman and Bondre's modification of Plowman maturity law | | | |
|---|---|---|---|---|---|
| | | Constants | | Per cent of 28 day | 7 day |
| | | A | B | | |
| 3,000(?) | 6,500 | 45·5 | 45·5 | 88·7 | 5,764 |
| 2,480 | 5,770 | 42·6 | 42·1 | 82·1 | 4,734 |
| 2,050 | 5,000 | 39·8 | 38·2 | 74·5 | 3,723 |
| 1,650 | 4,300 | 37·5 | 35·5 | 70·9 | 3,048 |
| 1,400 | 3,800 | 34·1 | 35·2 | 67·5 | 2,565 |

**Design**

# GAS-TURBINE STARTERS AND POWER UNITS




When Blackburn and General Aircraft Limited, Brough, took out licence agreements to make the Turbomeca range of gas-turbines, they proceeded to carry out some redesign on them, both to make them conform to British requirements and to make use of the Nimonic range of materials that had not been available at the time of the original designs. As a result considerable improvements in power and in power-to-weight ratio were obtained. The four types, Palas, Palouste, Artouste, and Turmo, were then developed with a common design of components to give a choice of types and sizes from a straight turbo-jet to a shaft turbine of about 750 h.p. The most recent addition to the range is the A129, now reaching its final development, which will have an output of about 900 h.p. How the different components can be put together is indicated in the diagram Fig. 1.

The Palas alone is rather small for most purposes and has therefore been used mainly as a gas generator for the rest of the range. The Palouste is being used in the Fairey Ultra-light helicopter and in air starters, and the Turmo in the Kaman helicopter and also as the power unit for a light-weight generator set. The engines offer a particular advantage in helicopters enabling tip-jet rotors to be used; these have an inherently balanced torque reaction removing the need for a separate anti-torque propeller at the tail of the machine as well as eliminating mechanical drives. Fig. 2 shows an Ultra-light helicopter about to land on a lorry.

**Fig. 1 Diagram showing the various arrangements of standard parts (which are similarly shaded for each unit) to form the engines of the Turbomeca range.**

**Fig. 2 The Palouste supplies the air for the tip-jet rotors of the Fairey Ultra-light helicopter.**

However, it is on air starting and industrial uses that the present emphasis is laid. The starting of large engines has always presented a problem and large turbo-jets are no exception. A convenient way is to use compressed air—which can be supplied from a smaller jet burning the same fuel. The Palouste is suitable for the latter role and has been developed for the purpose, both as a land unit and in an air-borne " pod." Air is bled from the compressor at about 45 lb per sq. in and fed to the air starter motor on the main engine. The method has the advantages that the air supply does not become exhausted after a few starts, as of course is the case when storage bottles are used, and no heavy electrical equipment is required. Moreover the air can be used to pressurise the cabin (since it is free from toxic gases) and also to run some auxiliaries. The Artouste can often replace the Palouste.

As a ground unit the engine is mounted in a

## *Continuing* Accelerated Curing

from experience that different Portland cements may have different rates of increase in strength from 7 to 28 days. If the Road Note 4 relationship between 7 and 28 day strengths of normally cured cubes is accepted as being sufficiently accurate for most practical purposes, then the relationship predicted from the accelerated cube strength is slightly different. I suggest that this is a further indication that accelerated curing curves prepared under any one set of conditions may have only limited application, and that such things as the ratio of aggregate to cement, type of aggregate, aggregate shape and source of cement—in other words all factors which affect the cube strength—may affect the accelerated cured strength curves. But, on the other hand, for many jobs, it may be considered that the correspondence between the 7 day curves calculated on the Plowman maturity relationship, the Road Note 4 relationship, and the experimental results given by Ordman and Bondre, is sufficiently close for practical purposes. I suggest, however, that the constants A and B given by Ordman and Bondre in their Table 3 and used in my calculations in my Table III, cannot be usefully employed.

In a letter to you following his article (ENGRG., 11 April '58, p. 451), Mr. Ordman has suggested that the essential requirement of a site test technique is constancy of accelerated curing. As a simple illustration of the site application of the boiling method evolved by Smith-Gander and myself, Fig. 3, attached, is a record of some results obtained during the construction of the foundations to a power station in the London area.

Another point that I would like to take up is that Ordman and Bondre state that the testing machine used was a 200 ton, hydraulic, electrically-operated machine which had a proving ring to determine the crushing loads accurately. I should like to set beside this statement an extract from the *Report of the Director of Road Research for* 1953. This report came to my attention some time after we had carried out, in 1954, a series of tests and found that a machine in which the loads were measured by the deflections of an elastic ring gave results lower than those obtained by other machines. The Director of Road Research reported that "Cases have been found in which different testing machines, although in agreement on calibration with proving rings, gave results on the same concrete sometimes differing by more than 10 per cent. . . . Two machines which incorporated elastic steel weighing rings for measuring the load, gave results about 10 per cent lower than those given by other machines."

Opinions differ on the matter of whether such machines should be used for compression tests on concrete, and I cannot agree that because a compression machine incorporates an elastic ring it necessarily measures the compression loads accurately.

Yours faithfully,
T. N. W. AKROYD,
Chief Engineer.

Constructional Services Limited,
123 Victoria Street,
Westminster,
London, S.W.1.
25 April, 1958.

*Editor's Note:* A letter from Professor J. W. H. King on this subject appeared on p. 324 of our issue of 14 March and one from Dr. J. M. Plowman on p. 419 of our issue of 4 April last, in addition those referred to in Mr. Akroyd's letter.

**Production**

# ACCURATE TUBES

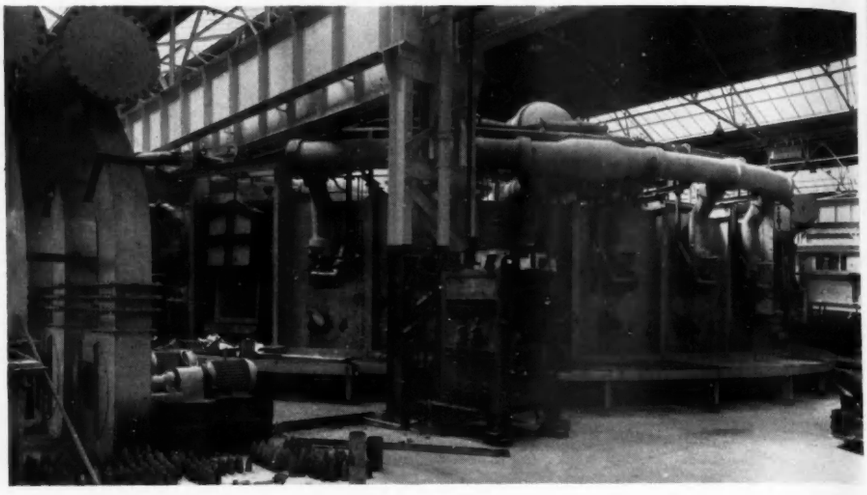
Before the Second World War tubes for the manufacture of ball and roller bearing races were imported, and it was not until 1941 that production was undertaken in this country. As a war-time measure the tubes were made on existing plant by the Talbot Stead Tube Company Limited, a member of the Tube Investments Group. In 1950 it was decided to install specialised equipment at the Eagle Works, Desford, near Leicester, of Tubes Limited, another Tube Investments company, and in 1954 the manufacture of bearing tubes was concentrated there. Eagle Works are very highly mechanised, and are capable of producing more than 40,000 tons of hot-rolled tubes a year.

Eagle Works are equipped for the manufacture of hot-finished tubes between 2 in and 5½ in outside diameter, to closer tolerances than can be obtained by most methods. The tubes are mainly in two qualities, nickel-chromium-molybdenum case-hardening steel and 1 per cent carbon-chromium through-hardening steel, both grades being used for bearing manufacture, but the works are equally suitable for making thick-walled tubing in low or high-carbon steels for a variety of other purposes where accuracy is important. The process used imposes some limitations on the ratio of wall thickness to diameter of the products, and the range which can be produced is from 4 to 1 to 12 to 1, depending on the steel specification. Limits of accuracy on outside diameters are: on tubes up to and including 3 in o.d., ± 0·015 in, and on tubes over 3 in and including 4 in o.d., ± 0·020 in. On tubes over 4 in o.d. the accuracy of the outside diameter is ± ½ per cent. Wall thickness is controlled to within 5 per cent of nominal, including eccentricity.

### HEATING AND PIERCING

The raw material of the works is steel in the form of round bars which are received by road and rail, and stored in an outside stockyard. A 7½ ton Clyde crane, with an Allen West magnet serves the stockyard, and places bars on a table forming part of a conveyor leading to the mill.

Inside the mill building bars are diverted to any one of four 24/28 in Noble and Lund cold-sawing machines, which cut them into billets of suitable lengths, as previously determined by weighing; the lengths are from 4 ft 6 in to 9 ft 6 in. On the discharge side of the saws further conveyors converge to a single line leading to the billet-heating furnace. Handling in the sawing section is by semi-automatic equipment made by Brookes (Oldbury) Limited, another T.I. company.



**A gas-fired rotary hearth furnace heats the billets ready for piercing.**

Billets are heated in a rotary-hearth furnace built by the Salem Engineering Company Limited, which can heat up to 25 tons of steel an hour to a temperature of 1,150° to 1,250° C. The furnace hearth has a mean diameter of 45 ft and the hearth proper is 11 ft 6 in wide. Firing is by town gas at present, but the furnace is also equipped for burning gas oil or heavy fuel oil. There are four zones in the heating chamber, each one being arranged for individual temperature control. Instrumentation by Honeywell-Brown instruments and Electroflo gas and air flow controls gives fully automatic temperature maintenance. Charging and discharging are by automatic machines operated hydraulically by Keelavite equipment, and fully interlocked with each other and with the furnace door gear.

Heated billets from the furnace discharging machine are fed to a chain conveyor which lifts them to a pneumatic hammer type centring machine, made by the Head Wrightson Machine Company Limited. This machine, which is fully automatic in operation, dimples the end of the billet to facilitate the start of piercing.

From the centring machine the billets pass to the inlet table of a two-roll piercing mill. This mill, built by the Head Wrightson Machine Company to designs supplied by the Aetna Standard Engineering Company, of Pittsburg, U.S.A., is basically of the well known Mannesmann type consisting of two barrel-shaped rolls inclined to the horizontal axis, which roll the billet over a hard alloy steel point supported at the approximate centre of the rolls by a mandrel bar. Because of their oblique setting, the rolls cause the material to be driven forward as well as rotated, and so forced over the point and bar to produce a tubular shell known as a bloom.

An important feature of the piercer is the close guiding provided for the bloom; this contributes to the high degree of dimensional accuracy of the pierced product. A 2,000 h.p. Metropolitan-Vickers motor drives the mill.

### ELONGATING

After piercing, the mandrel bar is withdrawn, and the bloom is kicked into a short transverse chain conveyor, which carries it to the next operation, elongating. This is done by an Assel mill, so called after its inventor, Mr. Walter Assel, of Canton, Ohio, U.S.A. The Assel mill is essentially a three-roll cross-rolling mill which elongates the billet over a mandrel bar, the diameter of which controls the inside diameter of the tube. A bloom arriving at the Assel mill is clamped while a pusher inserts a mandrel bar, the clamp is then released, and a second pusher feeds the bar and bloom into the mill, which rolls the bloom down on to the bar, so reducing the wall thickness and outside diameter, and elongating the bloom. Adjustment of the three

**A Mannesmann type two-roll mill does the initial piercing of the billet.**

## *Continuing* Turbine Starters

trailer complete with its control panel, and is fitted with silencing equipment. Hand starting can be carried out without difficulty in all weathers—it has been tested down to −40° C—and the set wheeled to wherever it is required. Connection to the main engine starting motor is made through a flexible hose stored in the trailer. For air-borne service the engine is mounted in a pod, as was mentioned earlier, and in this form has a total weight of about 970 lb. The units are guaranteed to give 2,000 starts between overhauls. When the Artouste is used it can be fitted with a generator and so can be used to test electrical equipment as well as hydraulic power services and cabin pressurisation.

A scheme that is being developed at the present time is for a complete mobile ground servicing unit capable of carrying out all the tests already mentioned and also of moving the aircraft on the ground while at the same time providing all the passenger interior services normally obtained from the main engine. Such an equipment would be of particular use with the larger jet aircraft, the noise of which is beyond the limits generally acceptable when on the ground, and whose main engine running would therefore have to be kept to a minimum. As an alternative to towing, the air supply could be fed to small air turbines driving the wheels to enable taxi-ing to be carried out.

The Palouste engine has been fitted with a Houchin alternator to give a power unit with an output of 250 kW for a gross weight of under 3 tons, or just over 27 lb per kW. Such a lightweight unit could easily be transported by air and would form a useful power supply in remote stations.

rolls in a radial direction enables a range of wall thicknesses to be produced for a given mandrel diameter, and the angle of the rolls relative to the pass line can also be varied to give greater or lesser degrees of feed through the mill. The Assel mill, which is powered by a Metropolitan-Vickers 2,000 h.p. d.c. motor, was supplied direct from America by the Aetna Standard Engineering Company.

After elongation, the tube and mandrel are conveyed to a stripper, similar to a conventional drawbench, which automatically draws the mandrel through a hole in a steel plate, leaving behind the tube, which is too large to pass through the hole. The mandrel is conveyed to an automatically operated cooling tank, and the tube goes on to the next operation. The mandrel stripper and cooler were also supplied direct from America by Aetna Standard.

By the time the tube has been stripped from the mandrel it has lost too much heat to be processed further without re-heating. It is therefore conveyed to a Priest walking beam re-heating furnace, fired at present on town gas, but also arranged for burning fuel oil if required. There are two heating zones in the furnace, each of which is separately controlled by Electroflo instruments, and the discharge temperature is approximately 950° C.

## SINKING AND SIZING

Immediately after leaving the re-heating furnace, tubes pass to a " sinking " mill. This consists of a number of roll stands, each with two rolls having semi-circular grooves, which roll the outside diameter of the tube and reduce it. The tube is not supported internally, and the reduction is thus a true " sinking " to use the tube trade term. The axes of the rolls are at 45° to the horizontal, and alternate pairs of rolls are arranged to the right and left of the vertical centreline. This, as in a continuous bar rolling mill, has the same effect as turning the tube through 90° between each pass. Up to 11 stands can be set up in the mill, which was built by Head Wrightson to Aetna Standard design, and is driven by a 500 h.p. Crompton Parkinson slip-ring induction motor.

After passing through the sinking mill a tube is reduced in outside diameter though the wall thickness is substantially unchanged; it is therefore also increased in length to some extent. The nature of the process is such that the tube is also inclined to be oval in shape, and the next stage is therefore to size it and correct any small discrepancies in outside diameter. For this purpose the tube passes to a two-roll cross-rolling mill, which has the rolls inclined to the horizontal pass line of the tube. Inlet and outlet tables support and constrain the tube while it is rotating through the mill, and skew rollers are provided in the inlet table to give a rotation to the tube to assist its entry into the sizing rolls. The mill, complete with inlet and outlet tables, was supplied from America by Aetna Standard, and is driven by two 75 h.p. d.c. English Electric motors, one to each roll.

After leaving the rotary sizer, the production flow line divides. Carbon-chrome steel tubes of the through-hardening type go to a Head Wrightson water cooler and are then taken to a 400 kW electric spheroidising furnace for heat treatment in a controlled heating and cooling cycle, to produce a structure of small carbide spheroids evenly dispersed throughout a matrix of ferrite. A Clifton and Baird 42 in saw alongside the cooling bed enables samples to be cut from the hot tubes for dimensional and quality checking.

Parallel with the cooling bed is a town gas-fired Priest furnace used, by controlled cooling, to produce the so-called " blocky " structure of the carburising grade of tubes. The furnace is provided with a hydraulically operated walking beam mechanism, and the hearth is divided into pockets which can contain up to 24 tubes, depending on their size. The beam " walks " every 7½ minutes. There are five individually controlled heating zones in the furnace. Passage through the furnace takes about 1½ hours, and the tubes are discharged at a temperature of approximately 450° C.

## FINISHING

All tubes then pass to two-roll straightening machines made by W. H. A. Robertson and Company Limited (a T.I. company), and are then cut to length, weighed and finally, as a check on material specification, spark tested.

A small proportion of the output is made into smaller and thinner sizes by cold reducing. This is done in a machine which has something in common, in principle, with the older Pilger mill, in that it has semi-circular taper grooved dies, which are used to compress the metal of the tube walls against a tapered mandrel. In the cold mill, however, the tube is rotated and fed forward in small increments, while the dies are rolled back and forth over the tube. The flow of metal under compression is uniform throughout the entire wall thickness, giving a denser, more consistent grain structure, which results in improved machinability, surface finish and a very close limit of eccentricity.

## SERVICES

Electricity is taken from the mains of the East Midlands Electricity Board at 11 kV, 50 cycles, the control gear being centralised in an air-conditioned substation. The high-tension switchgear is of British Thomson-Houston manufacture, and low-tension power is supplied by two 750 kVA, 11,000/415 V transformers feeding English Electric switchgear. A d.c. supply is obtained from a 500 kW steel tank rectifier made by the General Electric Company Limited.

The 2,000 h.p. motors which drive the piercing mill and the Assel mill are each fed from their individual steel tank mercury arc rectifiers. A Ward Leonard set is provided for the pusher motors on the inlet table of the Assel mill. The roll motors in the reheat and blocky-structure furnaces are of Laurence Scott manufacture, and are fed from frequency converters at a frequency of 5 cycles per second.

Gas is brought through a special 14 in pipeline 10,000 yards long from the works of the East Midlands Gas Board and metered into the works at a pressure of 24 in water gauge by a Holmes Connersville meter.

Cooling water is circulated by Worthington Simpson pumps from two ½ million gallon capacity reservoirs adjacent to the hot mill building. Both the inlet and the return pumps, which are duplicated, will handle 60,000 gallons an hour.

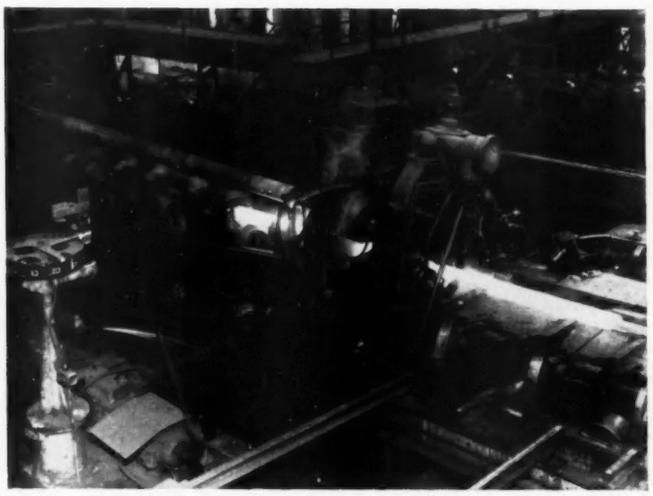
Compressed air is supplied to the works at 100 lb per sq. in from a central compressor house, with Bellis and Morcom and Alley and Maclellan compressors. The consumption of compressed air in the hot mill is approximately 800 cu. ft per minute.

## PRODUCTION BENEFITS

Some remarkable improvements in worker productivity have been made possible by the new plant. Taking the direct operating labour alone, productivity per worker at Eagle Works is about four times what it was in the former production units. If maintenance workers are included, the figure is about 225 per cent. Since the plant at Eagle Works is highly mechanised, and the Assel process is itself designed for high-speed production, improved productivity is only to be expected, and it was, of course, one of the reasons for laying down the plant. The problem of getting labour for hot, heavy and uncomfortable work was also an important factor in the decision to install the new equipment.

From the customer's point of view the plant has the advantage that it is more versatile than the former equipment, and subject to certain limitations of maximum and minimum size, it will produce tubes of which the outside diameter, wall thickness and bore can be of any required size; the old plant produced tubes varying by fixed steps. Since high-carbon and nickel-chromium-molybdenum steels are expensive, it is an advantage to a user to be able to buy tubes, made to close dimensional limits, of the size he requires to reduce machining to a minimum, and Eagle Works output is based on this need. The mill is, however, essentially a high-output plant, which is most economical when it is engaged on long run production.

**Pierced billets, then known as " blooms," pass by conveyor to the next operation—elongating.**



**Rolling on a mandrel in a three-roll Assel mill elongates the bloom into a thick-walled tube.**

*Continuing* **Production**

# FACILITIES FOR BUILDING LARGE WATER TURBINES

Until a few years ago large water turbines were only built in Great Britain on a limited scale, and solely for export, there being no home market until quite recently. In 1945 the North of Scotland Hydro-Electric Board started to develop Scottish water power on a large scale, and from the start they encouraged the manufacture of suitable machines in Scotland. Two English companies, already in the water turbine business, started to produce machines in Scotland, and the Harland Engineering Company, Limited, Alloa, decided to enter the water turbine field. A licence agreement with the S. Morgan Smith Company, York, Pennsylvania, U.S.A., was the first step, and manufacturing facilities at Alloa were augmented to allow production to start. Impulse, Francis and Kaplan turbines are now manufactured, and up to the present 37 machines have been supplied or are on order, the largest having a maximum output of 30,000 b.h.p. For 26 of the turbines supplied Harland also manufactured the generators, and in the remaining cases they co-operated with other British firms. Starting with the home market Harland have also been successful in selling turbines overseas, and in terms of h.p. just under 25 per cent of the water turbines and 40 per cent of the associated generators have been installed abroad.

Development of water power is calling for larger turbines, and pumped storage schemes require very large pumps. To meet the demand for this machinery and to raise the percentage of hydraulic generating and pumping equipment made at Alloa, Harland have built and equipped a new water turbine shop. As a result of this extension to their works the company can now undertake the manufacture of water turbines up to 60 ft in diameter and with outputs of up to 200,000 h.p. or more, together with associated equipment such as shut-off and relief valves, trash rakes and free-discharge valves. They can also build very large pumps, and are thus in a position to meet the requirements of hydro-electric and pumped storage schemes both for the present and for as far ahead as can be foreseen.

The new shop is 432 ft long, 63 ft wide and 45 ft high to the crane rails. Crane lifting capacity is up to 100 tons. Equipment installed in the new shop includes Hugh Smith plate bending rolls which will bend mild steel plate cold up to 2½ in thick and 5 ft. wide, or 1¾ in thick and 10 ft wide. A 24 ft Craven boring mill, a 30 in Craven centre lathe, and 8 in spindle Asquith horizontal boring machine and a 12 ft vertical boring mill are among other equipment in the shop.

**Water turbines, pumps and associated equipment up to the largest sizes likely to be required for some time can be built in the new shop of the Harland Engineering Company at Alloa.**

## Metals and Materials

### VINYL SHEETING REINFORCED WITH GLASS-FIBRE

A sheet material, consisting basically of a polyvinyl chloride coated glass-fibre mesh and called Plastoglass, has been placed on the market by Storey Brothers and Company Limited, White Cross Mills, Lancaster. It has taken some two years to develop the material in which a glass fabric is placed between two layers of vinyl film which are then fused together. The woven glass fabric is specially made for the firm and new machines, designed and built by the company's technologists and engineers, carry out the process of laminating and fusing the plastics together round the outside of all the threads.

The material has a high strength: weight ratio, is resistant to mildew, rot, bacterial attack, weathering effects, ultra-violet exposure and acids and chemicals, is dimensionally stable, has an attractive appearance and can be dielectrically welded using standard apparatus. Sheeting in a wide range of printed patterns is obtainable, and, of the two qualities available, one has a tensile strength of 200 lb per 2 in strip and the other 450 lb per 2 in strip. Even when a strip is nicked at the edge it is impossible to tear it across with the hands. Fire resistance is important in many applications and the advantages of glass under these conditions are obvious and do in fact overcome a serious disadvantage of most of the coated vinyl fabrics in the sense that there is no after-glow or burning of the charred product when a flame has been extinguished.

The new material is recommended for making shop blinds, canopies, tents of all types including those erected for roadside repairs by the electricity authorities and the Post Office, waterproof covers for machinery and other purposes on land, and for lifeboat and hatch covers and yacht and cabin cruiser covers and inflatable life-belts and dinghies, at sea. Other applications are in ventilation ducting for wet mines and fire hose-pipes which does not require the careful drying necessary to ensure that it does not lose its properties. In the consumer field, applications include material for deck-chairs, sun umbrellas, holdalls, inflatable beds and cushions, golf bags and beach shoes. In the travel-goods trade Plastoglass is being used by the Revelation Suit Case Company, Limited, and this luggage has, in fact, passed through the most arduous tests.

### A COLD-CASTING "METAL"

A liquid, stated to possess all the desirable properties of solid metal, is now available, under the name of Metolux, from M.G. Plastics Sales, 9 South Molton Street, London, W.1. It consists basically of thermosetting plastics, and a separate powder, containing special compounds and finely-divided metals, that combine to form a mouldable paste on setting. It is claimed that the material can be used on all metals as well as on wood, canvas and glass-fibre. It will not adhere to rubber so a flexible-rubber bowl is advocated for mixing.

Metolux withstands temperatures of up to about 450° F, and is recommended for the repair of motor-car bodywork, petrol tanks, cylinder blocks, and radiators, for the modification or repair of metal patterns in the foundry, for filling flaws and defects in steel sheets and plates or piping, and for similar work.

Supplied in tins, the separate constituents in their unmixed condition are stated to be impervious to the atmosphere and to have a shelf life, in a cool place, of up to 12 months.

### THE LACQ GAS FIELD

*700 million cu. ft per day*

Prospecting for oil in south-western France, the Société Nationale des Pétroles d'Aquitaine discovered, at a depth of 700 m (2,300 ft), a medium-sized oil field at Lacq at the end of 1949. This was soon exploited; at first the yield was about 300,000 metric tons of petroleum per annum but this has now fallen to 90,000 tons and the output is continuing to decline. The company, however, continued drilling to a greater depth and the discovery of a very large field of natural gas in December 1951, at a depth of 3,500 m (11,500 ft), was described by M. André Blanchard, the President of the Société, in a paper read in London before the Institute of Fuel on 10 April and entitled "Lacq: its Problems and Potentialities."

M. Blanchard stated that observations made at the end of 1955 had shown that the deposit was much more extensive than had been originally supposed and it was estimated that the recoverable reserves reached $5 \times 10^{12}$ cu. ft. At present about 35 million cu. ft of crude gas were being extracted a day. The gas contained 15 per cent of sulphuretted hydrogen and carbon dioxide, as well as methane, ethane, propane, butane and petrol. It was estimated that eventually 1,300,000 metric tons of sulphur would be produced a year, which would make France the third largest producer of sulphur in the world. When the working of the deposit was in full swing, namely, when the production reached 700 million cu. ft of crude gas a day, it was proposed to supply refined gas to Augoulême and Nantes, the central industrial districts of St. Etienne and the departments of Saône-et-Loire, le Doubs, and l'Isère; there was also a probability that refined gas would ultimately be supplied to Paris.

*Continuing* **Production**

# MAKING THE BEST USE OF COMPRESSED AIR

Five papers were presented at the conference on Improving Productivity by the Use of Compressed Air, organised by the Cornwall Section of the Institution of Production Engineers, on 9 and 10 April. The papers, from which extracts are given below, were: "Air Operated Equipment," by Mr. N. P. Watts, of Benton and Stone Limited; "Air Gauging," by Mr. C. J. Tanner, of Solex (Gauges) Limited; "A User's Experience," by Mr. J. Smedley and Mr. W. G. Wood, both of Rolls-Royce Limited; "Industrial Uses of Rotary Compressors," by Mr. J. Hodge, of Power Jets (Research and Development) Limited; and "Fire and Explosion Hazards in Compressed Air Systems," by Mr. A. C. Smith, of Shell Mex and B.P. Limited, and Dr. A. Thomas, of Shell Research Limited.

The application of compressed air in countless power and control installations has been simplified by the development of standardised pneumatic cylinders and controls. Quantity production of these components has enabled them to be supplied at a cost which is often only a very small fraction of the saving which results from their use. A purely nominal expenditure, for example, of as little as £1 to £20 can raise output by from 10 to 1,000 per cent. Such production increases are often possible on old machines, which, though sound and capable of good service, are too slow to meet present-day requirements.

Pneumatic operation and control can be of great assistance, too, where the handling time has become, as a result of higher speeds and feeds, the greater proportion of the total operating time. Air-operated locating, clamping and ejection are common examples of the use of pneumatic power to speed up component handling to meet the present-day machine and small-tool output potential.

A criticism sometimes levelled at compressed air is that while it is a convenient and versatile power medium, it is expensive. This is a matter for discussion, but there is no doubt that compressed air is expensive if it is wasted, a feature which it has in common with every other power medium. Wastage due to bad maintenance is, however, all too often encountered. It pays to remember that leaks equivalent to a hole $\frac{1}{8}$ in diameter in an air line at 100 lb per sq. in can waste air at about 25 cu. ft per min. By comparison, a 2 in bore double-acting cylinder with 1 in stroke could be operated over 900 times for the same consumption of air. Good preventive maintenance pays dividends.

## GAUGING

For many years it was thought that the major advantage of air gauging was that it could be used where contact with the component should be avoided, as with deformable or delicate parts. It is now recognised that the true quality of air gauging is in the use of air to amplify and report and not, in general, in its use for actually taking the measurement.

All applications of air gauging are, of course, of the comparator type, giving readings by comparison with a master of known size. They can be applied in many different ways. Air gauging can, for example, be used by a machine operator or setter to assist in machining a component by measuring it during or after machining; it can be used for setting check gauges, or as a feed gauge where slide movements are used to produce the required dimension. Air gauges can also be used for line inspection, often combined to cover a number of critical dimensions, enabling tool wear to be ascertained and corrective action to be taken. Another well-known application is the linking of a gauge to a machine to give automatic sizing, stopping the machine when the required dimension is reached. It is also possible to arrange air gauges to give feed-back control, so varying tool or other movements to keep a component within specified limits.

## FINDING THE PROS AND CONS

Good and bad can be found in everything, and compressed air is no exception. It is the user who can see more clearly than anyone the pros and cons of pneumatics, and it should be emphasised that although much of the work needed to improve the use of pneumatics falls naturally to the makers of equipment, they cannot solve all the problems on their own; users must co-operate fully. Rubber hose, for example, is available in oil resistant grades, which will overcome the difficulties caused by oil in the air lines attacking the hose, yet it is a fact that many users do not take advantage of the availability of suitable rubber.

On the other hand some users complain that certain problems have not been solved, and ask that solutions shall be found. Automatic drain taps in air lines, for example, can gum up with oil in a few months, and unless the valves are opened at regular intervals, they will cease to operate. To give manual attention is too costly, so there is a call for drain taps which will work for longer periods without attention. The same objection has been applied to oil filters, and some users have asked for lower costs of air compression, improved circuits and connections to reduce leakage losses, and better means of safeguarding operators where any risk is present.

## ROTARY COMPRESSORS

The main type-division of compressors is into positive displacement and aerodynamic types. In the former, which includes reciprocating compressors, the gas to be compressed is admitted into a space which is then closed and reduced in volume by mechanical means. In the aerodynamic compressor the principle is one of converting velocity head into static pressure by aerodynamic means. In the past the supply of compressed air at pressures of 50 lb per sq. in and upwards for industrial use has been mainly by means of reciprocating machines, but the rotary type has been growing in popularity for some time.

Machines of the positive displacement rotary type now available include the Roots blower, the

# NOTICES OF MEETINGS

### Association of Supervising Electrical Engineers

HOVE
Film Evening. Brighton, Hove and District Branch. New Imperial Hotel, First Avenue, Hove. Wed., 28 May, 7.30 p.m.

MAIDSTONE
Annual General Meeting. Kent Branch. Royal Star Hotel, Maidstone. Thurs., 29 May, 7 p.m.

### British Computer Society

LONDON
Annual General Meeting and Presidential Address. Northampton College of Advanced Technology, St. John Street, E.C.1. Mon., 16 June, 5.30 p.m.

### Chemical Society

LONDON
"The History of the Isoprene Rule," by Professor L. Ruzicka. Imperial College of Science and Technology, South Kensington, S.W.7. Thurs., 5 June, 7.30 p.m.

### Combustion Engineering Association

GLASGOW
Discussion on "A Survey of Boiler Cleaning Methods," at 10.30 a.m. and a Discussion on "A Comparison of Space Heating Systems," at 2.30 p.m. Scottish Region. Grand Hotel, Charing Cross, Glasgow, C.3. Wed., 18 June.

### Helicopter Association of Great Britain

LONDON
"Turbine Helicopters," by D. L. Hollis Williams. 4 Hamilton Place, W.1. Fri., 6 June, 6 p.m.

### Incorporated Plant Engineers

LONDON
Debate on "In Planning a New Factory the Plant Engineer and Not the Architect Should Have the Final Authority." London Branch. Royal Society of Arts, John Adam Street, Adelphi, W.C.2. Tues., 3 June, 7 p.m.*

BIRMINGHAM
Open Discussion on "Ideas and Problems." Birmingham Branch. Imperial Hotel, Temple Street, Birmingham. Fri., 30 May, 7.30 p.m.

### Institution of Civil Engineers

LONDON
Annual General Meeting. Tues., 10 June, 5.30 p.m.*

### Institution of Electrical Engineers

LONDON
"Standardisation of Control Facilities for the British Grid Communications, Indications and Telemetering," by P. F. Gunning; and "The Development of Communication, Indication and Telemetering Equipment for the British Grid," by G. A. Burns, F. Fletcher, C. H. Chambers and P. F. Gunning. Supply Section. Wed., 28 May, 5.30 p.m.*

ABERDEEN
Annual General Meeting and Film Evening. Scottish Centre. Robert Gordon's Technical College, Aberdeen. Fri., 30 May, 7.30 p.m.

### Institution of Engineering Designers

LONDON
"Engineering Design: The Background and Basis of Contemporary Life," by Hugh Clausen. Manson House, 26 Portland Place, W.1. Thurs., 12 June, 6.30 p.m.

### Institution of Mechanical Engineers

CARDIFF
"Light Mechanical Engineering in South Wales," by H. A. V. Bulleid; and "Some Mechanical Equipment in the Heavy Industries of South Wales," by W. F. Cartwright and I. S. Scott-Maxwell. Ordinary Meeting of the Institution. Rearden Smith Lecture Theatre, Cardiff. Wed., 18 June, 10 a.m.

### Institution of Public Health Engineers

LONDON
Informal Discussion Meeting. Caxton Hall, off Victoria Street, S.W.1. Mon., 2 June, 6 p.m.
Summer Meeting. Annual General Meeting, at 4.45 p.m. Tea at 5.15 p.m. Discussion on "The Hogsmill Valley Works of the Hogsmill Valley Joint Sewerage Board," at 6 p.m. Caxton Hall, off Victoria Street, S.W.1. Fri., 13 June. (A visit to the Hogsmill Valley Works, near Surbiton, Surrey, will be paid on Saturday morning, 14 June.)

### Royal Institution

LONDON
"Drilling Deep Holes into the Earth," by Dr. T. F. Gaskell. Wed., 11 June, 9 p.m.

### Royal Meteorological Society

LONDON
Various short papers including "The Use of Balloons in Atmospheric Pollution Research," by D. H. Lucas, G. Spurr and F. Williams; and "The Hydrogen Content of Atmospheric Air at Sea," by E. Glueckauf and G. P. Kitt. Wed., 18 June, 5 p.m.*

### Royal Society

LONDON
"The Institute of Aviation Medicine": a lecture by Group Captain W. K. Stewart. Thurs., 29 May, 4.30 p.m.*

### Royal Society of Arts

LONDON
"The 1958 Brussels Exhibition," by Charles Hadfield. Wed., 28 May, 2.30 p.m.

### Women's Engineering Society

MANCHESTER
Annual General Meeting and Film Evening. Manchester Branch. International Club, George Street, Manchester. Wed., 11 June, 6.45 p.m.

**The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated.** Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, W.C.1. (LANgham 5927.)
British Computer Society, 29 Bury Street, St. James's, London, S.W.1.
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke Street, St. James's, London, S.W.1. (WHItehall 5536.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, S.W.1. (ABBey 5160.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland Place, London, W.1. (LANgham 8847.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Public Health Engineers, 118 Victoria Street, London, S.W.1. (VICtoria 3017.)
Royal Institution, 21 Albemarle Street, London, W.1. (HYDe Park 0669.)
Royal Meteorological Society, 49 Cromwell Road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Women's Engineering Society, 25 Foubert's Place, London, W.1. (GERrard 5212.)

## *Continuing* Production

oldest of the group; the Bicera supercharger, which is new and not yet in extensive use; the Lysholm compressor, which has operational advantages but is difficult to produce without special-purpose machines; and the vane type, an old-established machine now more prominent because of the introduction of the oil-flooded version.

In the aerodynamic group the compressors are of two main types, centrifugal and axial. Both are similar in principle, in that the work input to the rotor causes a change in whirl velocity of the air, which is converted to pressure. The main difference is that the centrifugal machine makes use of the centrifugal force field produced by the rotation to help the energy conversion process; the axial type does not.

In all cases the compressor must be considered as only a part of the complete plant; the driving means must also be taken into consideration as a part of the whole. The type of compressor most suitable for a particular duty depends on too many factors for rigid rules to be laid down.

### SAFETY

Air compressors and associated equipment have a very good safety record, and they are far from being regarded as dangerous even when maintenance falls below the highest standards. Disastrous fires and explosions have, however, taken place and it is important to know the conditions in which such an accident is possible. Explosions caused by mechanical failure of members containing the air, through such causes as internal corrosion, for example, are not peculiar to compressed air equipment, but the presence of inflammable materials—primarily mineral lubricating oils—is a matter which should receive proper attention.

Incidents in compressed air installations can be divided roughly into three classes; fires, explosions and detonations. In the case of the first two either can lead to the other under suitable conditions. Some of the elements of compressor explosions are not fully understood at present, the source of ignition being the most mysterious. It appears, however, that a metal or a metal oxide surface at temperatures of around 240° C can ignite a mixture of lubricating oil and compressed air, and there are certain features of both design and operation which are of importance in promoting safety.

Design should be such, for example, that oil cannot remain in pockets in areas of high temperature, and that all parts of the system, especially those near the discharge valves, should be accessible for cleaning. The use of rust-resisting materials or coatings on the nearer elements of the discharge system might be considered, to prevent aggregation of deposits based on oil-soaked rust.

One obvious direction in which a reduction in the fire and explosion hazard may be sought is the use of lubricants with greater resistance to fire than mineral oils. However the cost is likely to be greater and there is also some possibility of toxic dangers. Keeping the temperature down will reduce vaporisation of oil and therefore concentration, and laboratory experiments suggest that for complete security, discharge temperatures should not exceed 150° C.

In operation it is important to see that the rate of oil feed is the minimum consistent with proper lubrication; that inlet air should be effectively filtered, to reduce the quantity of solid matter capable of agglomeration with oil; and the system cleaned and inspected at intervals.

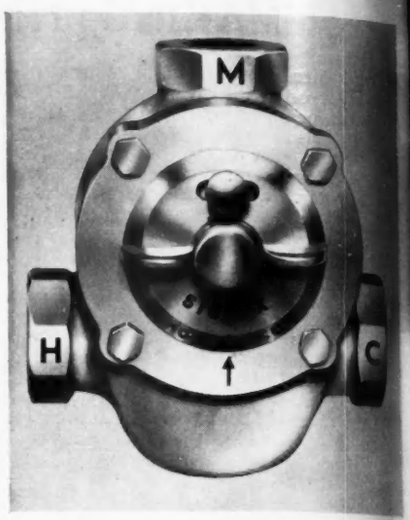
## Engineering at Home

### CONTROL BY MIXING

A range of valves for keeping hot water for heating systems at a constant temperature is made by Sigmund Pumps Limited, Team Valley, Gateshead, 11. The valve fits into a boiler by-pass between flow and return and blends some of the cooler water with the hot. The main flow to the hot-water cylinder does not pass through the valve. A dial on the front of the unit allows selection of the flow temperature required, between the limits of 95 and 194°F. The valves bear the name "Sigmix"; a type S is shown in the illustration.

The valves are supplied as standard with left-hand hot inlet from the boiler, right-hand cold inlet for the return from the heating system, and top vertical mixed-flow port—viewing from the temperature control side. A bi-metal spiral in the upper part of the valve casing controls a double clack valve in the lower part; the valve either opens the inlet port from the boiler and closes the return port from the heating system, or vice versa, so maintaining an even temperature by differential mixing. The setting of the flow temperature to the desired figure is effected by loosening the hand screw securing the dial, setting the dial to the required position and resecuring. Each division alters the flow temperature by about 10° F.

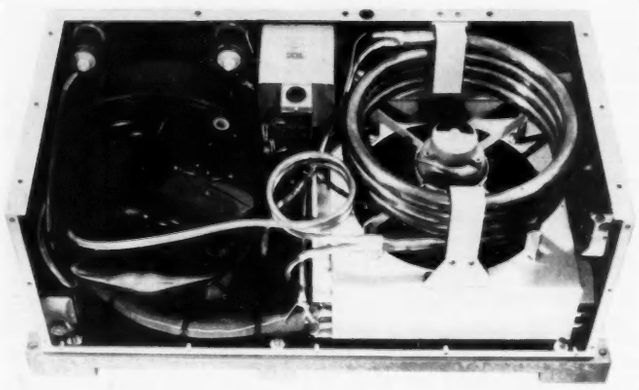
The mixing valve is available in two designs—type S and type P. Type S is normally supplied for domestic applications. The makers claim that it is ideally suited to forced circulation central heating because of the low pressure drop through the valve (equivalent to about 20-25 ft of piping). Type P is intended for larger industrial or commercial installations. The makers claim that by using this type of hand-setting control in various individual circuits, instead of motorised valves, initial costs can be greatly reduced.




### AIR CONDITIONER

A room air conditioner for hot countries with relatively high humidities has been designed by Temperature Limited, Fulham, London, S.W.6. It is called the "Tropical" and can be installed in existing buildings. Water-cooling is used.

The dimensions of the unit are 11 in deep, by 28 in wide, by 14 in high. Corrosion proofing has been applied to the sheet metal face and plastics are used for the fascia plate. A semi-contraflow evaporator performs moisture removal and cooling. The contraflow condenser uses a finned tube within a copper pipe. A single phase compressor motor absorbs 1·2 kW.



### ELECTRIFYING GARDENING

The use of electricity in the garden was displayed on the stand of the Electrical Development Association, at the Chelsea Flower Show (20-23 May). The main emphasis was on amateur greenhouse heating. This included thermostatically controlled tubular, convector, and fan heating equipment to provide an average house temperature of 45° F, with the outside temperature at 20° F, and complete frost protection when outside temperatures reached 0° F. Ventilation in the greenhouse was provided with a thermostatically controlled fan, which cooled the atmosphere inside on warm days. The use of open and closed benches showed how maximum growth could be maintained with an average house temperature of 45° F. The first used bench warming only. The second showed how special climates could be provided for plants requiring higher air temperatures. Both soil warming and space heating by plastics covered soil-warming cables were employed, the air temperature being controlled by rod type thermostats. For the amateur who grew horticultural crops for sale, the supplementary lighting of tomatoes and cucumbers was shown; a 400 W high-pressure mercury vapour lamp was used.

Among the labour saving equipment exhibited were a rotary tiller, chain saw, lawn verge cutter, hedge trimmer, and long grass cutter. A soil steriliser was also shown.

ENGINEERING

Published every Friday by ENGINEERING LTD. at 36 Bedford-street, London, W.C.2.
Telephone: Temple Bar 3663.
Telegrams: Engineering Lesquare London.

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